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Engineering Library

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See page 101. 3456

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See Advertisement page 48, April 12. 3402

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6196
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See Full Page Advertisement April 5th.

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See half-page Advertisement page 91, April 19.

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The works, which have the extensive frontage to Bow Creek of 400 ft., contain an area of nearly two acres. The buildings are conveniently arranged for economical construction and are equipped with modern Shipbuilding and Engineering Plant.

The whole of the fixed plant, machinery and fixtures, as also the

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Tenders, which must be on the form attached to the particulars, must be delivered by Twelve noon on WEDNESDAY next, MAY 1st, at the Office of the AUCTIONEERS, 133, High Holborn, W.C. 1.

The Works may be viewed by orders only, to be obtained of Messrs. FORBES & SON, Solicitors, 19, Mark Lane, E.C., and of Messrs. FULLER, HORSEY & CO., Mechanical Auctioneers and Valuers, 133, High Holborn, W.C. 1. K 943

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In each case the commencing salary will be fixed according to qualifications and experience.

The maximum salary is at present under revision.

Male candidates must be exempt from, or disqualified for, military service.

Canvassing will be considered a disqualification.

Application Forms, which must be returned not later than May 10th, may be obtained from

R. DEMPSEY,
Clerk to the Governors,
1, Selborne Road,
Walthamstow, E. 17. L 220

Woolwich Polytechnic. Head of Engineering Department REQUIRED, to commence duty in September. Commencing salary, £450.—For further particulars apply PRINCIPAL. L 173

An Experienced Accountant REQUIRED thoroughly conversant with modern factory organisation, especially progress methods; must have initiative, and be a capable organiser.

Live men only need apply.

Applicants engaged on Government work or living outside 10 mile radius will not be considered.

Write in first instance, giving age, experience, and salary required, quoting references, to L 194, Offices of ENGINEERING.

Wanted, by Firm of Engi- neers employed solely on Government work, Male CLERK who can take charge of books (double entry) and supervise workmen's time and piecework accounts. No person already on Government work will be engaged.—Apply, stating experience, age and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5128. L 208

Wanted in Government Office (London), Civil Engineering Draving Office ASSISTANTS. Salaries from £3 to £6 per week and overtime. Applicants must be ineligible for general Military service and should give particulars of experience and age, with references or copy of any testimonials, to BOX 1325, WILLING'S 125, Strand, London, W.C. 2. L 152

Chemist, First-class, Required for large manufacturing concern. Must be well up in metallurgy (especially steels) and photo micrography.—Write, giving details of experience, salary required, &c., to L 173, Offices of ENGINEERING. No one already engaged on Government work or residing more than ten miles away need apply.

Metallurgist, or Metallurgical CHEMIST, for controlled firm of non-ferrous metal manufacturers, north-east coast. Must be a live man not afraid of work, preferably with previous works experience and knowledge of copper alloys. Excellent post-war prospects for right man. Address, stating age, full details of experience and salary required, L 100, Offices of ENGINEERING.

Works Manager Wanted, for large Engineering Works; one having experience in Heavy Machine Tools preferred.—Address, giving full particulars as to previous experience, salary desired and copies of references, L 34, Offices of ENGINEERING.

Shipyard and Marine Engi- neering WORKS MANAGER REQUIRED by firm in the South of England. Good prospects for experienced Engineer having previously held similar position.—Apply, giving resumé of experience, age, and salary required, to L 196, Offices of ENGINEERING.

Wanted, for Modern Steel Foundry, experienced and energetic FOUNDRY MANAGER with thorough knowledge of the production of light castings by modern methods. No one already on Government work will be engaged.—Address, stating age, experience and salary required, L 63, Offices of ENGINEERING.

Wanted, by Firm of Engineers in London, ASSISTANT MANAGER or FOREMAN. Must be capable organiser and have had general machine shop experience, including capstan work.

Excellent prospects for suitable man.

Salary £300 to £400.

No one at present on Government work or residing more than 10 miles away need apply.

Address, sending copies of testimonials, L 207, Offices of ENGINEERING.

A Supply Company has a VACANCY for a CHARGE HAND for running and maintaining Diesel and Gas Plant. State experience and salary required, and whether ineligible for Military service, to L 50, Offices of ENGINEERING.

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Required, by Firm of Con- sulting Works Layout Engineers, a thoroughly Capable MAN with ideas and experience on General Works Layouts. Preference given to one who has received his discharge from the Army. General draughtsmanship and mechanical engineering training essential, with analytical and observant methods. Young preferred. This is not for the "duration of war," but permanent, and the position gives scope for an excellent future.—Reply, giving all experience, education, age, salary required, &c., BOX 567, T. B. BROWNE'S ADVERTISING OFFICES, 163, Queen Victoria Street, E.C. 4. L 198

Engineers' Storekeeper WANTED, for Controlled Establishment, must be over 30, able to control Stores Staff and must have had previous experience.—State age, particulars of your experience, salary expected, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 76. No person already employed on Government work will be engaged. L 76

Wanted, Engineer for Iron and Steel Works comprising Blast Furnaces, Gas Power Plant, Open Hearth Steel Plant and Rolling Mills. Must be good organizer and possess sound technical and practical experience in modern works. No person already on Government work will be engaged.—Apply, in confidence, stating age, experience and salary expected, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 5134. L 195

Engineer Required. Knowledge of Heating and Ventilation, capable of supervising erection of Steam Plant. State age, salary and experience. No one already engaged on Government work or residing more than 10 miles away need apply. — Address, L 214, Offices of ENGINEERING.

Aeroplane Factory Progress DEPT.—ENGINEER REQUIRED, capable of taking charge of Progress Dept. of large Aeroplane Manufactory Works (London). He must have had a thorough engineering works training, be well acquainted with modern methods of production, and be very systematic in his books. He will be directly responsible to the superintendent of the factory and have entire control of the progress staff in the various depts. A good salary will be paid to a capable man. Apply, stating age and salary required, and giving full particulars of past experience, positions held and when free to commence. No one need apply who is living more than 10 miles away or engaged on Government work.—Address, K 985, Offices of ENGINEERING.

Wanted, Ten or Twelve efficient PROGRESS or RUSH MEN for work in Scotland, previous experience in Modern Machine and Fitting Shops necessary. State age, experience, qualifications and salary required. No one already on Government work need apply.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5147. L 209

Draughtsman (Jig and Tool) WANTED for large Aeroplane works in Lancashire district, knowledge of press work, tools for automatics (Cleveland and Acmes, Capstans) and all woodworking machines. No person already on Government work will be engaged. Only experienced men need apply, stating age, full experience, and salary required, at your nearest EMPLOYMENT EXCHANGE, quoting No. A 5013. L 9

Draughtsman Required to TAKE CHARGE of Coal Washery Department. Experienced man only need apply.—Full particulars in the first place to K 694, Offices of ENGINEERING.

Draughtsmen, Two Seniors REQUIRED on Machine Tool Design. Good salary paid to first-class men. Progressive and permanent job. No one already on Government work will be engaged.—Apply, with full details, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5089. L 74

Draughtsmen.—Several Men REQUIRED for Mechanical Engineering work for Controlled Factory in Midlands. Must have had some practical experience. Knowledge of Textile or Printing machinery desirable, but not essential. Good opportunities for suitable men. Also several good JUNIORS, with Drawing Office experience. No one already on Government work will be engaged.—Apply, stating full particulars of salary required, age, experience, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5081. L 75

Draughtsmen.—A Controlled Establishment in the West Riding of Yorkshire, engaged on important high priority work, REQUIRE the SERVICES of a competent MAN, with first-class experience in General Engineering work; also experienced MAN for medium size machine tool work. No person already on Government work will be engaged.—Apply, stating full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning A 4965. K 869

A Lady Tracer is also REQUIRED. The above positions are permanent to reliable individuals. No person already on Government work will be engaged.—Apply, stating full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning A 4965. K 869

Draughtsmen Wanted, for Aeroplane work in Government factory. Previous experience in aeroplane design not absolutely necessary, but sound knowledge of mechanical principles essential. Good prospects for right men. No person already on Government work will be engaged.—Apply, stating experience, age and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting reference No. 4120. L 171

Draughtsmen.—Required for North of England iron and steel works, one or two DRAUGHTSMEN experienced in steel works and rolling mills machinery. No person already employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, quoting No. A 5110 and this Journal. L 147

Draughtsman Required for Aeroplane Factory, London district. Previous experience of aircraft work not essential. No person resident more than 10 miles away or already on Government work need apply.—Address, stating age, particulars of experience, and salary required, L 174, Offices of ENGINEERING.

Wanted, Draughtsmen for drawing electrical apparatus in a Government Department at Portsmouth. Applicants to have at least two years' experience in a commercial drawing office. Wages 67s. 6d. (inclusive) per week of 42 hours, plus overtime.—Address, BOX 1340, WILLINGS, 125, Strand, London, W.C. 2. L 159

Wanted, First-class Assistant DRAUGHTSMAN, for Engineering works at Greenwich, permanent and progressive appointment for suitable man. Must be ineligible for general Military service.—Address, L 163, Offices of ENGINEERING, stating experience and salary required. No one already on Government work or resident more than 10 miles away need apply.

Concrete Shipbuilding.— Reinforced Concrete DRAUGHTSMEN WANTED, in London district, for large Admiralty Contract. No one residing more than 10 miles away or employed on Government work will be engaged. —Address, stating age, experience and salary required, L 129, Offices of ENGINEERING.

Draughtsmen.—Applications requested for good experienced Mechanical DRAUGHTSMEN. Those with Crane work experience preferred.—State age, salary, experience, and when at liberty, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4426. No person already on Government work will be engaged. L 85

Wanted, Capable Mechanical DRAUGHTSMAN. Must be good engineer, with workshop experience and technical training, for controlled establishment on General work, Manchester district. No person already engaged on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4526. L 81

Draughtsman, Senior Mecha- nical, able to start at once on important war work. Liberal remuneration and very attractive prospects are offered to a rapid worker with designing ability. Motor lorry or tractor experience an advantage. No one already on Govt. work or living more than 10 miles away need apply.
AIR TRANSPORT, 54, Kingsway. L 230

Draughtsman Required, with good experience in design of Steelworks Machinery preferred, although applications from high-class men with other experience would be considered. No one already on Government work will be engaged.—State age, experience and salary required and when at liberty, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4694. K 393

Draughtsman, Mechanical Engineering, WANTED for Controlled Factory in Scotland. Experience in Motor Vehicle or Machine Design preferable but not essential.—Apply, stating age, experience and salary expected, to nearest EMPLOYMENT EXCHANGE, mentioning this Journal and No. L 335.
No person already employed upon Government work will be engaged. L 335

First-class Draughtsman WANTED, for post near London, as Checker of Jig and Tool work. Must be experienced and reliable. No person already on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5096. L 108

Draughtsmen Required, for Aero Engine and Motor Car Design, by a large firm in South of Scotland. Excellent prospects for first-class men. Good salary. No person already employed on Government work will be engaged.—Apply, stating full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5069. L 31

Heating and Ventilating.— REQUIRED, Competent DRAUGHTSMAN and ENGINEER, capable of preparing schemes and supervising erection of work. State experience, age and salary required. No one already engaged on Government work or residing more than 10 miles away need apply.—Address, L 215, Offices of ENGINEERING.

A Constructional Draughts- MAN REQUIRED immediately at Aylesbury. Salary £200 to £300 per annum.—Full particulars to PUTMAN, Southern Works, Aylesbury. L 212

Draughtsmen and Assistant DRAUGHTSMEN REQUIRED, on Aeroplane work. Good mechanical experience essential. No one already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting K 978, and this Journal.

Senior and Junior Draughts- MEN REQUIRED, accustomed to the Design of Electrical Machinery. No one engaged on Government work or residing more than 10 miles away need apply.—State age, training, and experience and salary required to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 4.

A Technical Assistant, with Works or Drawing Office experience, is REQUIRED for the Commercial Office of a large Engineering works in the Midlands. Applications from discharged soldiers possessing the necessary qualifications will receive special consideration.—Apply, stating salary required and giving full details of experience, to nearest EMPLOYMENT EXCHANGE, quoting this Journal and L 180. No one already on Government work will be engaged.

Wanted Technically Trained YOUNG MEN as Assistants in Production Departments of large Industrial Concern (Government Controlled). Permanent and progressive positions. Preference given to men having Engineering, Drafting or Laboratory training. No one on Government work will be engaged.—Apply, with full particulars of qualifications, experience, age and when free, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4744. L 70

Three Locomotive Fore- MEN and One ASSISTANT BOILER SHOP FOREMAN Required for the Federated Malay States Railways, for three years service, with possible extension. Age not to exceed 35 years; preferably unmarried; the loss of an eye or of a left arm not a disqualification. Salary, £280—£10—£350, with a duty allowance of £50 a year. Free passages.

The Locomotive Foremen must be Fitters by trade, preferably with running shed experience both as regards running and repairs of locomotives. Will be required to take charge of a Locomotive Shed and District, including all locomotives and machinery as regards maintenance and repairs, and also the charge of all locomotive working and staff in the district under the District Locomotive Officer.

The Assistant Boiler Shop Foreman must have served his time as Boiler Maker in an Approved Shop, and subsequently as journeyman. Preference will be given to a man well up in repair work. Must be well versed in modern practice both in construction and the use of compressed air and hydraulic tools. Experience as an Inspector would be valuable.

Candidates should apply to their nearest EMPLOYMENT EXCHANGE, giving full particulars of training and experience, quoting No. A 5130, and mentioning this Journal. No person engaged on Government work or eligible for the Army need apply. L 204

Foreman Required for Ship- yard employing about 100 hands, must be capable, taking full control of present work, mainly repair and alteration of iron and wood craft, making iron and wood structures other than ships, must have thorough knowledge woodworking and engineering machines, capable laying out and extending present plant and scope of work now undertaken. No person already on Government work will be engaged.—Apply, stating age, salary required and full particulars experience with copies of testimonials, which will be returned, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5127. L 166

Machine-Shop Foreman Re- QUIRED. Those engaged on Govt. work or residing more than 10 miles away need not apply. London N.W. district.—L 217, Offices of ENGINEERING.

Hardener Wanted to Take charge of full and modern plant with progressive firm of machine tool makers in Midlands; must be experienced in modern hardening methods of high speed and special steels; also in carbonizing and used to mass production. Permanent position with excellent prospects for man having necessary knowledge and experience.—Apply, stating age, qualifications, and salary required, to nearest EMPLOYMENT EXCHANGE, mentioning No. A 5132. No person already on Government work need apply. L 176

Foreman or Junior Foreman REQUIRED, capable of fixing contract rates for fitting and erection of large steam turbines.—Apply through your nearest EMPLOYMENT EXCHANGE, giving age, experience and salary required, and mentioning No. A 5152. No person already employed on Government work will be engaged. L 210

STRESSES IN TURBINE BLADING.

By GERALD STONEY, F.R.S.

THE blading in steam turbines is exposed not only to stress due to centrifugal force, but also to stress due to the pressure of the steam on the blades and to vibratory stresses.

The stress due to centrifugal force is easily dealt with, since it is merely due to the weight of the blade, and for brass blades is :

$$f_c = \frac{R^2 h d}{234{,}000} \quad . \quad . \quad . \quad (1)$$

and for steel blades :

$$f_c = \frac{R^2 h d}{255{,}000} \quad . \quad . \quad . \quad (2)$$

where :

f_c = stress in pounds per sq. in. due to centrifugal force.
R = revolutions per minute.
d = mean diameter in inches.
h = blade height in inches.

In considering this stress, which is a steady stress, due regard must be had to the fact that in some blade fixings the strength of the fixing is less than the tensile strength of the blade, and in some cases the blade is cut away at the root to provide for the blade fixing. Further, in some types of construction the yield-point at which the blade begins to draw out of its fastening is reached considerably before the yield-point of the material of the blade; and this is sometimes accentuated by the blade's tending to become to a slight degree loose, owing to repeated heatings and coolings. This is especially liable to occur with blades of brass or other alloy, which have a much larger coefficient of expansion than the steel of the turbine rotor. Equations (1) and (2) give the tensile stress on a parallel blade just where it is fixed into the rotor; and in considering what stress is safe due regard must be had of the method of holding the blades. By the use of taper blades, which are sometimes employed at the exhaust end of large turbines, this stress can be reduced to about two-thirds of the value given above. The factor of safety allowed should be at least three, taken on the yield-point of the blade with its fastening, and at least four on the ultimate strength of the fastening and blade.

The next stress on the blades is that due to the pressure of the steam on the blades; and this is the force that drives the turbine. Many methods have been proposed for the estimation of this stress, and all are more or less approximate; the method here given has been found convenient in practice.

In designing a turbine, the following quantities amongst others are generally known :

R = revolutions per minute.
Q = maximum lb. steam per hour.
$a = u/c$ velocity ratio, or ratio of blade speed u, to steam speed c in ft. per second.
η = blade efficiency.

The relation between the blade efficiency η and the velocity ratio a for turbines of modern design, is given in Fig. 1, in which η is the actual blade efficiency with no allowance for leakage, windage, bearing friction, &c.

In an impulse turbine the work done in foot-pounds per second by the steam on the blades per stage of the turbine is given by :

$$W = \frac{Q c^2 \eta}{7200 g}$$

and the tangential force in pounds is :

$$T = \frac{Q c^2 \eta}{7200 g u}.$$

Remembering that $u = \frac{R d}{230}$, this becomes :

$$T = \frac{Q \eta R d}{53.5 a^2} \times 10^{-6}.$$

A very useful unit in these calculations is the blade-width w, that is, the width of a row of blading measured axially in the turbine. As blades of various sizes with similar shapes and angles are, or should be, similar in any given type of blading, it follows that the moment of resistance to bending varies as w^3, and also that the circumferential pitch of the blades $\lambda = b w$, where b is a constant depending upon the type of blading. In impulse blading b is generally between 0·5 and 0·6, and in reaction blading it is between 0·6 and 0·7.

Fig. 1. TURBINE EFFICIENCY CURVES. BRAKE TO STEAM (ADIABATIC). NO FRICTION, WINDAGE OR LEAKAGE ALLOWED

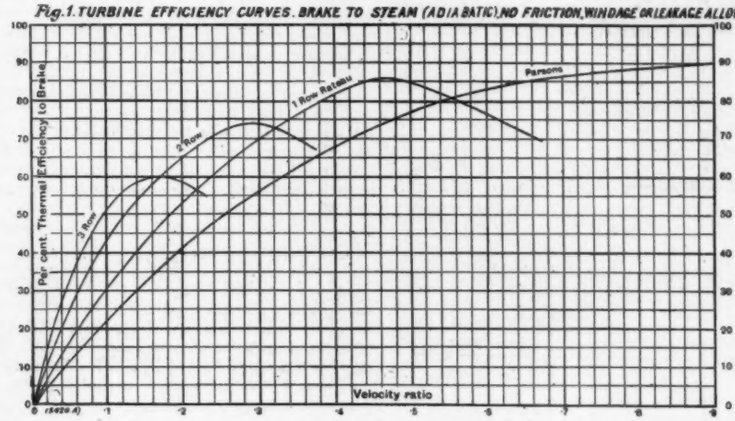
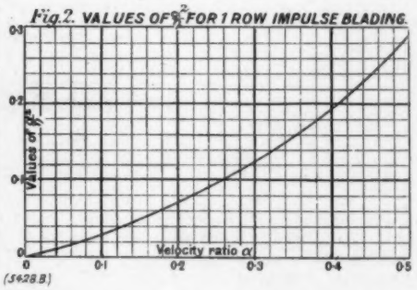


Fig. 2. VALUES OF $\frac{a^2}{\eta}$ FOR 1 ROW IMPULSE BLADING.



The number of blades in a ring where there is admission all round is therefore :

$$\frac{\pi d}{\lambda} = \frac{\pi d}{b w}$$

and the force on each blade is :

$$t = \frac{Q \eta R b w}{168 a^2} \times 10^{-6} \quad . \quad . \quad . \quad (3)$$

If Z is the resistance modulus of the blade section when 1 in. wide and f_s is the stress on the blades due to steam pressure, then the moment is $f_s Z w^3$, and is equal to $\frac{t h}{2}$. Putting this value for t into the above equation, we have :

$$\frac{h}{w^2} = 336 \times 10^6 \frac{a^2 f_s Z}{Q \eta R b} \quad . \quad . \quad . \quad (4)$$

Values of $\frac{a^2}{\eta}$ for impulse blading for various values of a derived from Fig. 1 are given in Fig. 2. Strictly speaking, these should be corrected for leakage; but in neglecting this correction we are keeping on the safe side, and in a modern turbine the leakage is small. This seems a difficult equation to work with; but in practice it must be remembered that usually the velocity ratio and blade shape are constant throughout the whole or a large part of a turbine, and therefore a, η, b and Z are constant; so that :

$$\frac{h}{w^2} = C \frac{f_s}{Q R} \quad . \quad . \quad . \quad . \quad (5)$$

The total tensile stress on the blade is then given by $f = f_s + f_c$; and here a distinction must be made between the strength of the blade and the strength of the way in which it is fixed into the rotor; in other words, of the blade fixing.

The stress due to steam pressures on the blade, or f_s, causes bending of the blade, and this combined with the centrifugal force f_c, gives the stress which must be allowed for at the weakest section of the root of the blade. On the other hand, so far as pulling the blade out of the rotor is concerned, only the centrifugal force f_c must be taken into account.

The factors of safety to be allowed in the latter case have already been dealt with; and similar factors of safety should be allowed for the combined stress due to centrifugal force and steam pressure in the case where there is complete admission of the steam all round the blades. Where there is partial admission, much higher factors of safety must be allowed for the stresses due to bending, on account of the intermittent action of the steam. In many cases between 10 and 12 is not too large a factor of safety to allow.

It may be mentioned that in moderate-sized turbines up to, say, 4,000 h.p., the bending stresses in the blades are rarely serious; but in large sizes, 15,000 h.p. and above, they often become of considerable importance.

In the case of partial admission, the value of $\frac{h}{w^2}$ must be multiplied by the proportion of the circle occupied by nozzles. As mentioned before, in practice it is found that $\frac{h}{w^2}$ can be made constant for considerable ranges in the turbine; and thus the blade widths suitable can be seen at once when the blade heights are known.

In two-row impulse blading, the work is divided between the two rows, so that approximately the work done in the first row is that due to the efficiency, as shown in the curve for one-row in Fig. 1, and in the second row as that due to the difference between the curves for one row and two rows. Thus if the velocity ratio is 0·2, the efficiency for the first row is 54 per cent. and for the second row 11 per cent., the sum of which makes the total efficiency of the two rows 65 per cent., as given on the curve. A similar arrangement holds for three rows.

In practice, the rows are generally made of the same width, or nearly the same; for if the first row is strong enough it is generally found that the others are also strong enough. The longer blades, however, may need to be reinforced at the root, on account of centrifugal force and vibration.

Another method, which is often convenient when partial admission is used and the velocity of the steam is above the critical velocity, is based on Rankine's formula for the flow of steam under these conditions. A similar formula has also been given by M. Rateau. This is, that the flow of steam, q lb. per second, is approximately proportional to the absolute pressure P in pounds per square inch, and that $q = 0{\cdot}0145\ P\ A$, A being the area in square inches.

The area for the steam per inch of the circumference may be taken as $0{\cdot}8\ h \sin\theta$, where θ is the exit angle of the nozzles and 0·8 is a coefficient to allow for the thickness of the nozzle plates, the overlap of the blade outside the nozzle and the divergence of the nozzle from the throat to the exit.

The tangential force T^1 per inch of circumference is then given by :

$$T^1 = \frac{P c^2 h \eta \sin\theta}{5500 u}$$

and

$$\frac{h^2}{w^2} = 11000 \frac{f_s Z a^2}{P b u \eta \sin\theta} \quad . \quad . \quad (6)$$

As such blading is often at the beginning of a turbine where the admission is very partial, a large factor of safety has to be allowed, on account of the intermittent action of the steam; and thus, as mentioned before, in such cases it is often found that a factor of safety of about 10 must be allowed,

while 4 or 5 is a sufficient factor of safety where there is complete admission.

In many cases the blade-fixing consists in cutting away the sides of the blade and putting it, with distance-pieces between the blades, into a dovetailed groove in the rotor. Such cutting away of the sides weakens the blade against bending stresses much less than might be supposed; and further, the blade is partly supported by the section-pieces between.

It can be seen that cutting away the edges of the blade does not weaken it much, and in some cases may even increase its theoretical strength, when we remember that $Z = \frac{I}{\sigma}$, where I is the moment of inertia of the blade and σ is the distance of the edge of the blade from the axis through the centre of gravity. Cutting away the edges reduces σ largely, and I only a little, as the edges are thin. Thus a certain amount of cutting away actually increases the strength of the blade; but in practice this amount must generally be exceeded, in order to provide sufficient bearing surface to take the centrifugal force. It is a case similar to the old conundrum of a square bar of iron supported on two props with the diagonal vertical and a weight hanging at the middle. If the fibre stress is found to be too high, how are we to increase the strength by the means only of a hammer and a chisel? The answer is: "Cut off the top and bottom edges."

In the foregoing, only the tangential force on the blades—in other words, the force that drives the turbine—has been considered; and the axial force parallel to the axis of the turbine, due to drop of pressure in the moving blades, has been neglected, since in impulse turbines it is generally small in amount. In impulse turbines the whole, or the greater part, of the expansion takes place in the fixed or guide blades, and there is therefore little drop of pressure in the moving blades; thus the axial stress—the stress parallel to the axis of the turbine—is small.

In reaction or Parsons blading, since there is equal expansion in the fixed and in the moving blades, the drop of pressure across the moving blades is considerable; the axial stress is therefore large, and under ordinary conditions is equal to or rather more than the tangential stress. In such reaction blading, since there is equal expansion of the steam in the fixed and the moving blades, equation (3) becomes:

$$t = \frac{Q \eta R b w}{84 a^2} \times 10^{-6} \quad . \quad . \quad . \quad (7)$$

for the tangential force only. Here a is the true velocity ratio or the ratio of the blade-speed to the steam-speed in either the fixed or the moving rows. In some books, the velocity ratio is taken as if the whole of the expansion were in the fixed row, as in an impulse turbine: it is therefore $1/\sqrt{2}$ of the above value of a, and care must be taken not to confuse the two.

Let T be tangential force on the blading and L the axial, Δp being the drop of pressure across either moving or fixed row, and V the volume of steam in feet per second.

$$T = \frac{2 \eta V \Delta p}{u}$$

and

$$L = A \cdot \Delta p$$

A being the area of the annulus.

Therefore:

$$\frac{T}{L} = \frac{2 V \eta}{u A} = \frac{2 \eta \sin \theta}{u} \quad . \quad . \quad . \quad (8)$$

since $\frac{V}{A}$ = axial velocity of the steam, or $c \sin \theta$, θ being the blade angle; and the forces on each blade have the same ratio. The resultant force on the blade, n, is then the resultant of these two forces, or:

$$n = t \sqrt{1 + \left(\frac{a}{2 \eta \sin \theta}\right)^2}$$

$$= \frac{Q R b w \eta}{84 \times 10^6 a^2} \sqrt{1 + \left(\frac{a}{2 \eta \sin \theta}\right)^2}$$

calling

$$\frac{\eta}{a} \sqrt{1 + \left(\frac{a}{2 \eta \sin \theta}\right)^2} = \beta$$

$$n = \frac{Q R b w}{84 \times 10^6 a} \beta \quad . \quad . \quad . \quad (9)$$

From this it follows, as equation (4) was derived from equation (3), that:

$$\frac{h}{w^2} = 168 \times 10^6 \frac{f_s Z a}{Q R b \beta} \quad . \quad . \quad . \quad (10)$$

Fig. 3 gives the relation between β and a derived from Fig. 1, θ being taken as 20 deg.; and since, of course, the minimum value of a in any section of the turbine must be taken, it is seen that between the values of $a = 0{\cdot}4$ and $a = 0{\cdot}6$, which are the usual minimum values in modern turbines, the value of β is 2·15, so that:

$$\frac{h}{w^2} = 78 \times 10.6 \frac{f_s Z a}{Q R b} \quad . \quad . \quad . \quad (11)$$

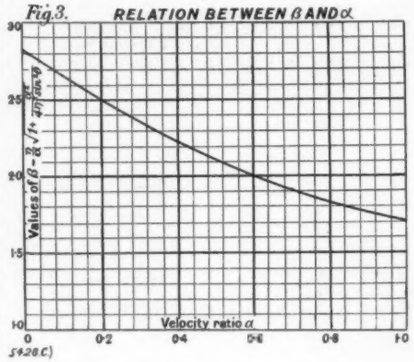
which gives the total stress on the blades due to the combined effect of pressure drop and reaction.

This acts at approximately 45 deg. to the axis of the turbine; but small variations of this angle have in practice little effect on the strength of the blades.

It is, of course, necessary to take the minimum value of a in a turbine, and not its mean value. In the usual form of stepped reaction turbine there is generally an appreciable difference between the minimum and mean values of the velocity ratio.

Until the present time, no account has been taken of the stiffening effect of the shrouding or lacing of the blades. Shrouding riveted on to the top of the blades cannot be considered rigid for small movements, and thus cannot well be taken into account in considering the stresses on the blades, and this is the type generally used in impulse blading. If such shrouding, which is generally of substantial section, could be rigidly fixed to the

Fig. 3. RELATION BETWEEN β AND α



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blades by silver soldering or brazing, the strength of the blades would be considerably increased, and their tendency to vibrate largely reduced. The difficulties in making a satisfactory and workmanlike job are, however, considerable.

In the case of reaction blading the usual practice is to silver-solder on lacing strips at intervals along the blades; but such lacing strips have not, in practice, sufficient rigidity to add much to the strength of the blade for resisting bending. Besides this, when the blade is of hard-drawn material it is annealed locally by the brazing-on of the lacing strip. The chief function of these lacing strips is to prevent the blade from vibrating, and in all types of blading some of the most serious stresses to which blading is subjected are vibratory stresses. Such stresses arise from many causes, one being partial admission of the steam; and even when there is nominally complete admission, irregularities generally occur as may be caused by the cylinder joint. Dealing with such difficulties is entirely a matter of practice, and even yet one hears occasionally of trouble due to vibration, especially at the exhaust end. For safety's sake, it is necessary that the natural period of vibration of the blades shall be a high multiple of the rate of revolution of the turbine.

Another important factor is, that the blading should not be too flimsy; that is, that the proportion of height to width should not be too great. In all structures it is essential that the design should be "substantial" and a "mechanical job." What it is that constitutes this is entirely a matter of practice; but it is obvious that a blade, say, $\frac{1}{2}$ in. wide and 8 in. or 10 in. high is flimsy and not substantial, while one only 4 in. or 5 in. high is all right.

In conclusion, the author would wish to express his thanks for help in the preparation of this article to the staff of the Manchester College of Technology and to various friends, more especially Mr. Arthur Morley and Mr. H. M. Martin.

TESTING MINERS' LAMPS.

IN the past, but probably with insufficient reason, American mine owners have been represented as showing inadequate attention to the safety and well-being of the mining population and taxed with unwillingness to take necessary precautions to safeguard the underground workings against loss. There is no evidence of carelessness or of improvidence in the management of their property to-day. Alertness and energy are everywhere displayed, but the claims of industry are equally recognised. On the scientific side the Bureau of Mines gives very efficient assistance. The Bureau is a very active body, eager to disseminate information and to give advice, ready to investigate new methods and to enforce regulations that will facilitate output, or minister to safety and efficiency. A recent proof of its solicitude on behalf of the mining industry is furnished by the publication of a bulletin, detailing the steps that have been taken to improve the efficiency and increase the practicability of a miner's electric lamp.* The open-flame lamp still finds occasional use as an illuminant in mining operations, and this potential source of danger is too frequently risked, when the poor illumination of the safety lamp becomes intolerable, or the workman finds his movements hampered by its use. Considering the inconvenience arising from the cumbersome nature of the Davy lamp, and the risk attending the use of the open flame oil lamp, the advent of the enclosed electric lamp, with its clear light, capable of being operated with comparatively small apparatus was hailed as a special boon for the miner, and the possibilities of danger underlying its frailty and weakness were overlooked or purposely ignored. To attach the tiny bulb to a miner's cap and strap a storage battery on the back, leaving the hands free, and the command of a good light at will, seemed an ideal arrangement especially suited to mining conditions. The advantages were so patent that the concealed risks were disregarded, but it is to be feared that the earliest examples of the new mechanism were exceedingly crude in construction and not unattended with danger to the unsuspecting wearer. The Bureau of Mines was not unmindful of the hazard so readily accepted, and soon after the introduction of the improved light showed that the incandescent wire in a broken bulb was capable of igniting an inflammable mixture of gas and air, demonstrating that only the frail glass of the lamp bulb stood between the miner and a catastrophe that involved injury to himself and comrades.

Convinced that the hazards of mining operations would be diminished by the use of a portable electric lamp that would give increased safety by eliminating the open flame, and provide more light in a convenient form than the safety lamp, the Bureau endeavoured to stimulate better design and construction by instituting careful investigations theoretical and practical, and establishing a system of attested approval that would be both useful to the miner and an advantage to the maker. With this end in view the co-operation of manufacturers was invited, many of whom submitted their lamps for examination and criticism. None of the original specimens was free from defect, but the joint efforts of the Bureau and makers have been so effective, that there is now no difficulty in procuring lamps which satisfy all the requirements of the Bureau. This improvement, too, has been effected in a comparatively short time, far shorter than would have been the case had the development been left to ordinary commercial exploitation and competition. On this result the Bureau is to be congratulated, the method of procedure has much to recommend it, and its final success shows that the policy was sound. The eagerness with which the

* Approved Electric Lamps for Miners. By H. H. Clark and L. C. Ilsley. Published by the U.S. Bureau of Mines. Van H. Manning, Director. Washington: Government Printing Office, 1917.

mining operatives have adopted the form of lamp bearing the official warrant of approval is most gratifying. This keenness proves that practicability has not been sacrificed to safety, a danger to which the officials were alive, for as the report points out, it was manifestly futile for the Bureau to urge the adoption of an impracticable device on the ground that its safety was assured. The present time, the tests and the requirements do not seem too onerous or too elaborate. The best proof of their fitness is the cheerfulness with which they are accepted by the makers. The general qualifications may be summed up as follows :—

1. The lamp must produce continuously for a definite period a suitable amount of properly distributed light. This condition will be generally suggested that the design and construction of the battery should be such, that it is capable of providing 300 discharges of 12 hours each. It is not possible to test this capacity by actual trial, but the makers are prepared to guarantee a life of twice the prescribed period.

3. The electrolyte shall neither spill nor leak, and the weight of the entire apparatus shall not be burdensome. The average weight of the equipment of a "cap" lamp is about 4½ lb.: the "hand" lamp is somewhat heavier.

4. Further, the lamp equipment must be provided with an automatic safety device, so designed that whenever the bulb is broken, the lamp filament shall immediately cease to glow at a temperature liable to ignite explosive mixtures of gas and air. These requirements refer mainly to the behaviour of the lamp ; there are other specifications depending on the electrical arrangements and attachments, and on the light distribution, which can be more conveniently considered when describing the several methods of making the tests.

The first of the mechanical tests to which the lamp is submitted and perhaps the most important from the point of view of safety, applies to the device for securing sudden and complete extinction of the lamp filament on accidental fracture of the bulb. The plan most commonly adopted takes the form of a spring or springs that hold the bulb in circuit as long as the apparatus is intact, but cause it to fall out of circuit or to complete the circuit in another place when the glass is broken. The method of test is indicated in Fig. 1. The material part of the lamp is placed in a closed case containing a highly explosive mixture of gas and air, and while the filament is glowing with normal brilliancy the bulb is broken by a blow on a tool shaped like a miner's pick. To constitute a failure it is not necessary that an explosion should follow: if the filaments continue to glow, the lamp is held to be inadequately protected, and the particular device is condemned. The presence of a gas mixture is therefore unnecessary to the completion of the

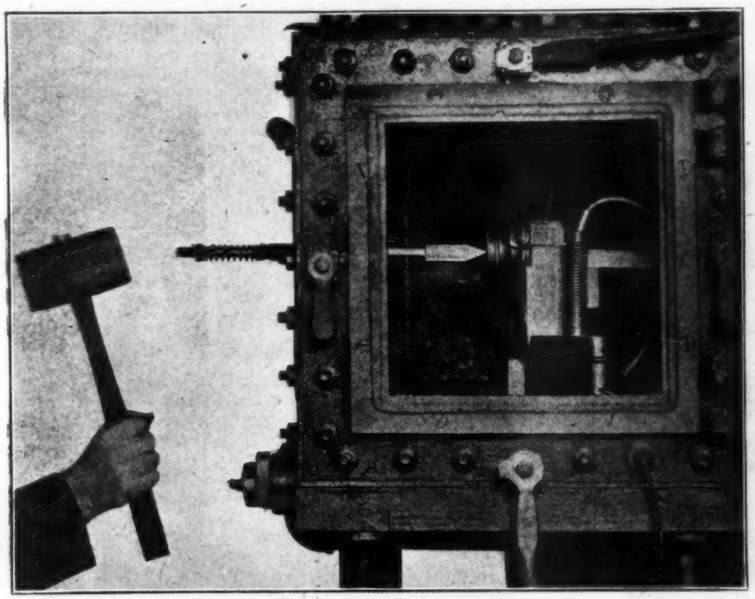


Fig. 1. Equipment for Testing Safety Devices of Electric Miners' Lamps in Explosive Mixture of Gas and Air.

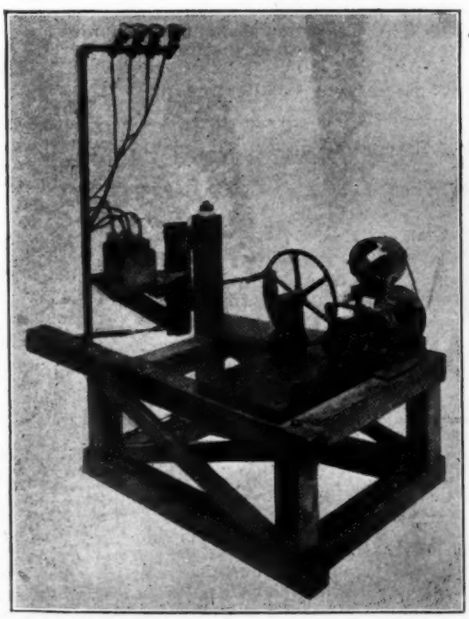


Fig. 2. Machine for Testing Non-Spilling Devices of Mine-Lamp Batteries, Assembled for "Picking Test."

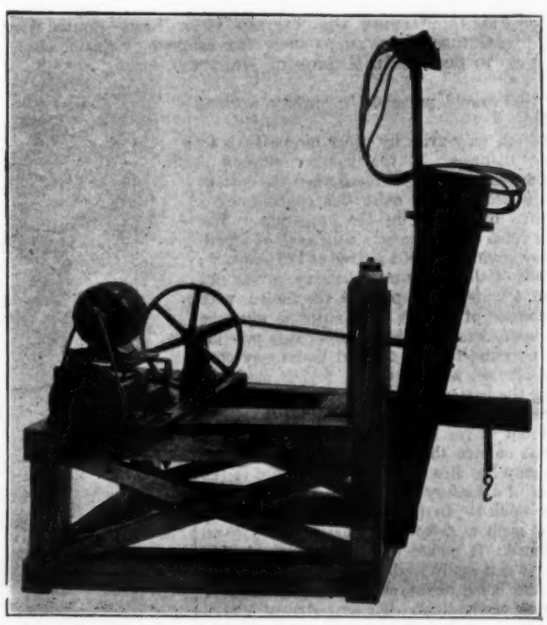


Fig. 3. Machine for Testing Non-Spilling Devices of Mine-Lamp Batteries, Assembled for "Shovelling Test."

first officially-approved lamp was issued in the spring of 1915, and within a little more than a year about 70,000 lamps of an approved type were in active service. Such lamps are now being installed at the rate of about 2,000 a week.

The minimum conditions that a portable electric mining lamp is required to fulfil have been modified from time to time, and the tests made more thorough and searching. This is the natural consequence of the effort to reach a high standard, but at the met if the lamp produces for 12 consecutive hours from one charge of battery, a light stream having an average intensity of light not less than four-tenths of a candle-power. In the case of a "cap" lamp the total flux of light must not fall below 1½ lumens during the 12 hours, and for a "hand" lamp not below 3 lumens during the same period.

2. The lamp must repeat this production with a minimum number of interruptions, and at a cost commensurate with the benefits received. It is test, and fracture is produced by other means, as by striking the bulb on any part with a hammer or swinging it violently against some hard object. If under any circumstances the safety device fails to act, rejection follows and new designs have to be substituted.

This test is very severe on the workmanship where springs are employed, because the Bureau demands that the lamp should be free from the chance of unexpected extinction. If there be any

loose contacts, or the springs be of too light a character, under this rough treatment the safety device designed for extinction may operate when it is not intended. The standard method of investigating the tendency to unexpected extinction consists in dropping a lamp, or the headpiece of such lamp, on a concrete floor from a height of 6 ft. This is a pretty severe test on the mechanical strength, for it might very well happen that some change of shape would be produced in the metal covering that would prevent the springs working as intended.

Gas ignition may arise by other means than by a glowing filament. If the battery current is excessive, sparks may be produced when the current is suddenly broken. To meet this contingency a limit has to be placed on the amperage. The maximum value of current for a single cell of a lead-acid battery, giving 2·5 volts is fixed at 125 amperes: for two cells of alkaline storage battery, giving not more than 4 volts, 85 amperes is the limit; with further increase of voltage the amperage must be proportionately less. To test whether it is possible for these currents to be exceeded under any conditions of service, a short circuit test is made by connecting the battery across an ammeter in series with a resistance equal to that which the lamp circuit would have, if a complete short circuit existed just outside the battery casing.

The Bureau has also directed its attention to the production of a battery from which the electrolyte cannot be spilled. In the case of a mining lamp equipment such a defect, may be more than an inconvenience: it points to inferior workmanship generally, it can easily lead to the deterioration of the cell, and bring about premature extinction or the lowering of the light. The criterion of a non-spilling battery is, that it shall not spill more than one full drop of electrolyte after being placed for 8 hours in those positions that seem most likely to promote leakage. The method of testing is thorough and designed to reproduce as nearly as possible the conditions in which the battery will be placed when in actual use by a miner engaged in either "picking" or "shovelling." Fig. 2 shows the testing machine as arranged for the "picking" test. Four batteries that have been allowed to stand in open circuit for an hour are grouped in an upright position on a horizontal platform; the electrical equipment being completely assembled and the lamps burning. This platform is hinged on a horizontal axis at a point 10 in. from the centre of the group, and so adjusted that it can be swung back and forth through a horizontal arc of 23 deg. This swinging operation is continued for two periods of an hour each, at the rate of 72 oscillations per minute. Fig. 3 shows the arrangement to simulate the motions accompanying "shovelling." Four cells are placed on their sides on a similar platform but the axis is hinged 40 in. below the centre of the group. The cells are swung through an angle similar to that in the preceding case, but only 48 times a minute. This test is continued for 3 hours with two interruptions for an hour. In addition to this rhythmical swinging, the batteries for the "cap" lamp equipment are dropped 20 times (if they survive so long) on a wooden floor from a height of 3 ft. If any battery develops a leak before it has been dropped six times, or if the four batteries could not be dropped on the average 10 times without material injury, a stronger battery jar has to be substituted. Since in many cases the lamps of various makers passed this test without the slightest leakage, there should be no difficulty in eliminating leakage defects from mining batteries.

From practice acquired in a laboratory it seems a very simple matter to make and maintain the necessary connections between the battery and the lamp, but that unfortunately is not the experience of the mining engineer. The terminals, the wires, the insulation, the whole apparatus, generally classed together as the "cords," proved in the early days to have so many sources of weakness, particularly by developing open circuits, partial or complete, after a brief period of service, that the adoption of the method of lighting by portable electric lamps was seriously delayed. Long after other weak points in the equipment had been eliminated, the cords continued to give trouble, and it is only by the determined co-operation of the examiners and the makers of the apparatus, that the evil has been

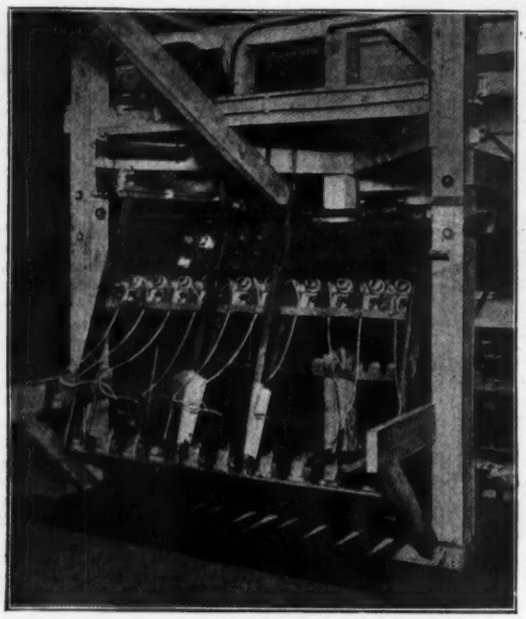


FIG. 4. MACHINE FOR TESTING MINE LAMP CORDS WITH GUIDES REMOVED TO SHOW THE AMOUNT OF SLACK GIVEN TO CORDS AND METHOD OF MOUNTING.

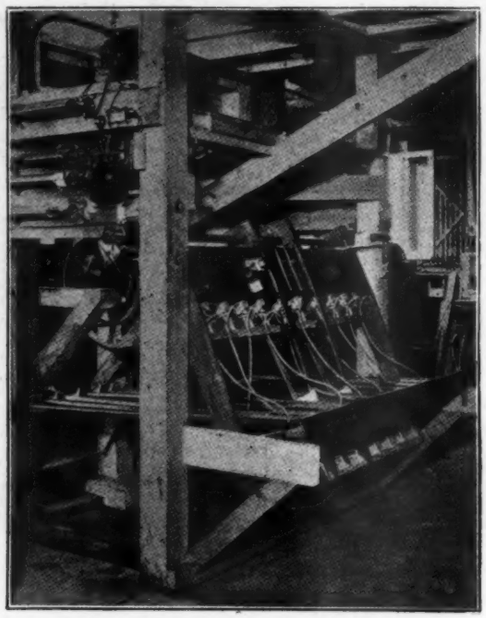


FIG. 5. CORD-TESTING MACHINE WITH GUIDES PLACED IN POSITION.

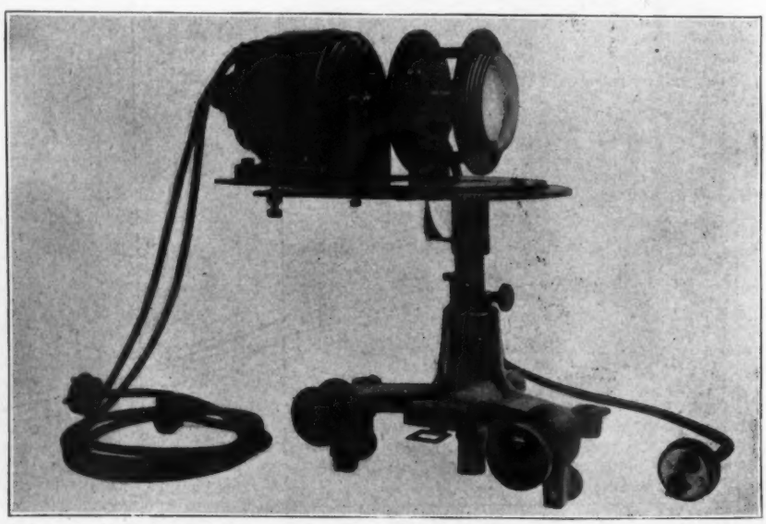


FIG. 6. DEVICE FOR ROTATING LAMP HEADPIECE WHEN MEASURING CANDLE-POWER.

THE SCIOTOVILLE BRIDGE OVER THE OHIO RIVER; THE CREEPER TRAVELLER.

MR. GUSTAV LINDENTHAL, NEW YORK, ENGINEER.

(*For Description, see Page* 451.)

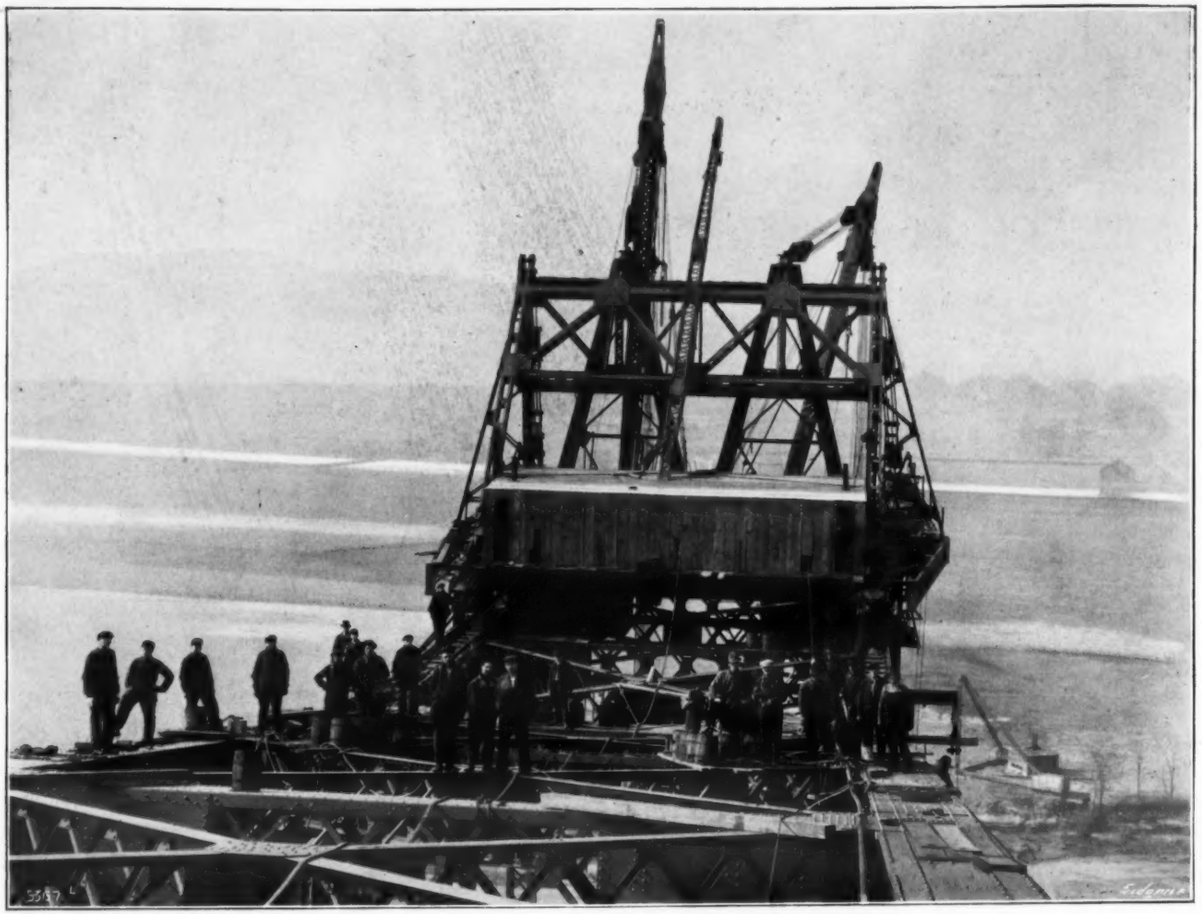
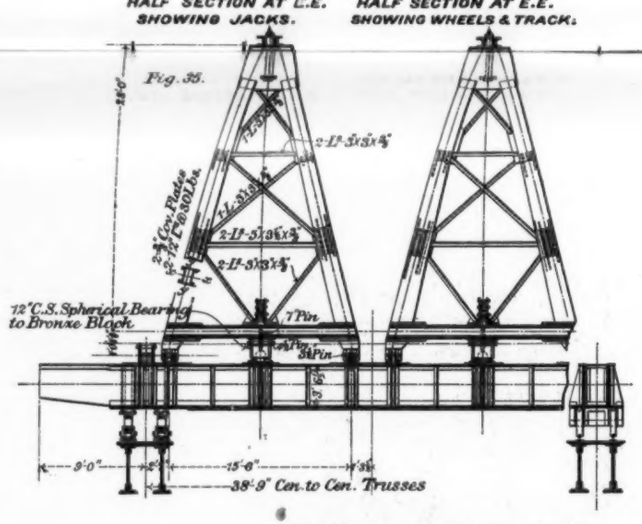


Fig. 34.

HALF SECTION AT L.L. SHOWING JACKS.

HALF SECTION AT E.E. SHOWING WHEELS & TRACK.



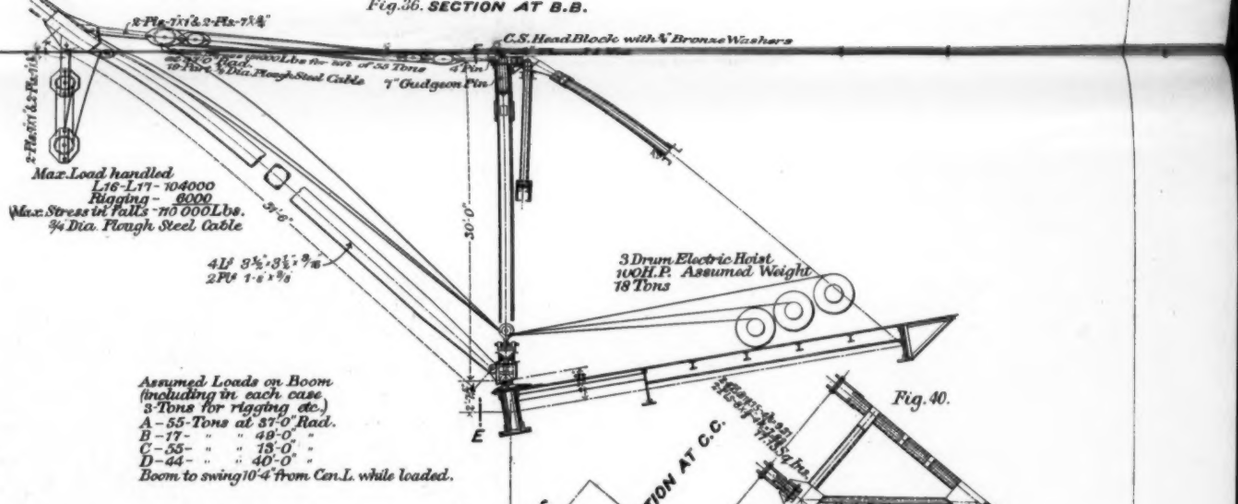
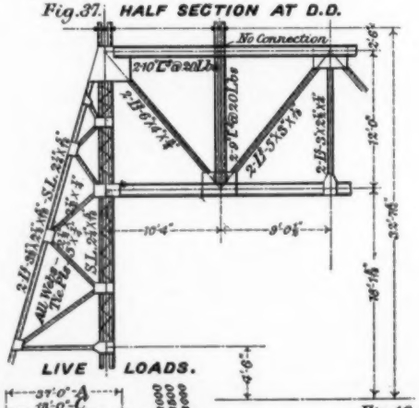


Fig. 36. SECTION AT B.B.
2-Pls. 7"x1" & 2-Pls. 7"x⅞"
C.S. Head Block with ¾" Bronze Washers
28-Part ¾" Dia. Plough Steel Cable
7" Gudgeon Pin
2-Pls. 11"x1" & 2-Pls. 11"x⅞"
Max. Load handled
L16-L17 - 104000
Rigging - 6000
Max. Stress in Falls - 110 000 Lbs.
¾ Dia. Plough Steel Cable
30'-0"
5'-0"
4Lf 3½"x3½"x⅜"
2Pl 1'-8"x⅜"
3 Drum Electric Hoist
100 H.P. Assumed Weight
18 Tons
Assumed Loads on Boom
(including in each case
3 Tons for rigging etc.)
A - 55 Tons at 37'-0" Rad.
B - 17 - " " 49'-0" "
C - 55 - " " 13'-0" "
D - 44 - " " 40'-0" "
Boom to swing 10'-4" from Cen. L. while loaded.
E

Fig. 37. HALF SECTION AT D.D.



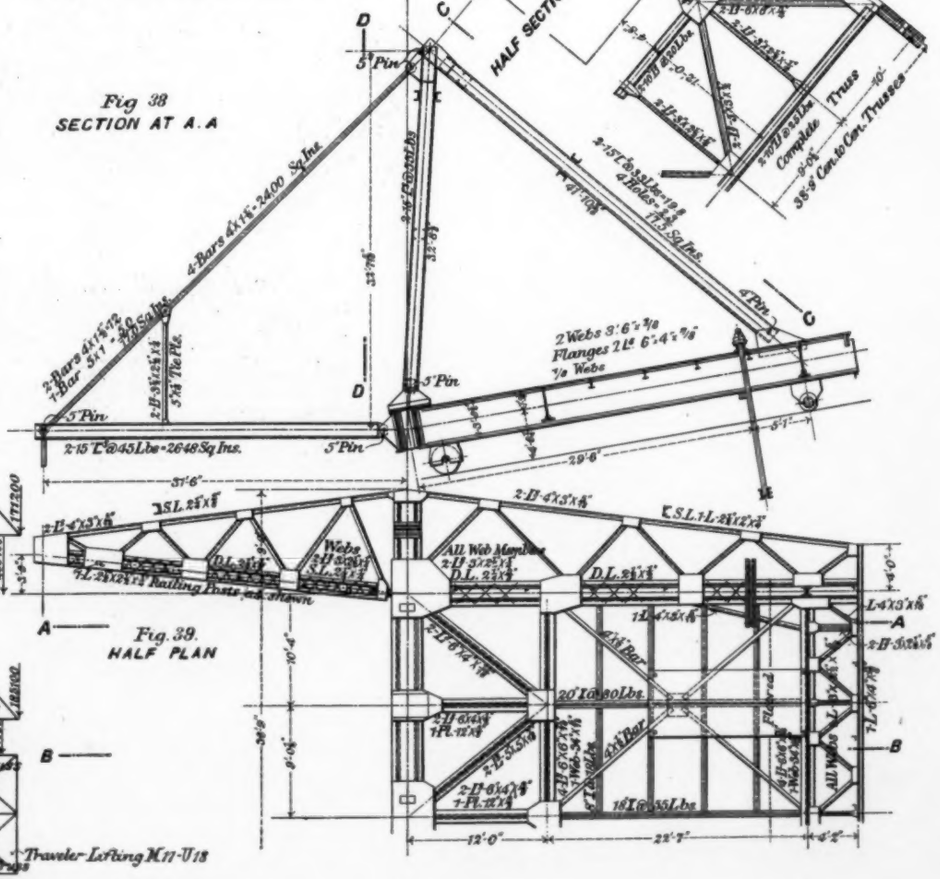


Fig. 40.

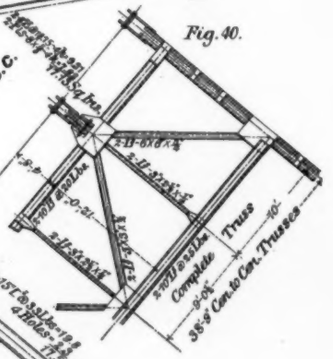


Fig. 39. HALF PLAN

MAXIMUM LIVE LOAD ON OUTRIGGER.

Fig. 41.

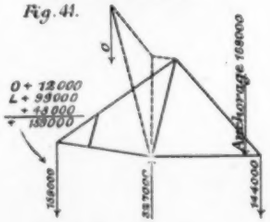


Fig. 42.
LIVE LOADS.

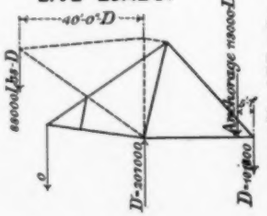


Fig. 43.
LIVE LOADS.

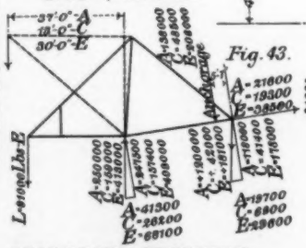
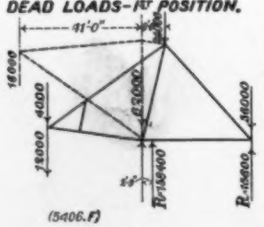


Fig. 44.
DEAD LOADS - 1ST POSITION.



DEAD LOADS - 2ND POSITION.

Fig. 45.

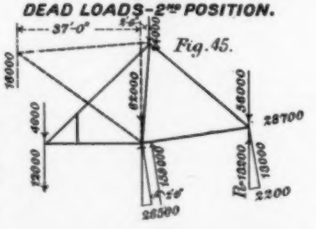


Fig. 46.

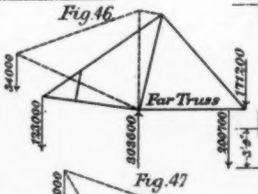


Fig. 47.

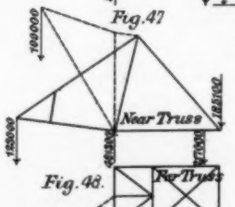
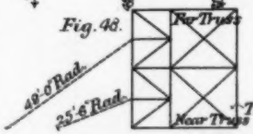


Fig. 48.



effectually overcome. A main trouble was traced to the means adopted for attaching the wire to the headpiece and to the battery respectively. The severe strains to which the electrical connections were submitted had not been properly appreciated. Reinforcement was naturally given at the points where the cord left the battery casing, and again when entering the lamp headpiece, but the device never proved satisfactory in practice. Where flexible conductors have to be employed, the junctions frequently develop trouble, and the true remedy is usually difficult to find. The authors of this report point out that in some cases, the earlier types of armour supplied were so weak that they failed more quickly than the cord they were intended to protect.

Protracted examination showed that the wires were apt to break by the continual swinging and swaying of the miner's body, even before the insulation was damaged, and suggested that the strength and fitness of the connections in their entirety, as well as the character of the reinforcement would be best tested by submitting the completed equipment to the same kind of motion and abrasion that is encountered in mining operations, though the speed, frequency and amplitude of the imitated motion might be exaggerated in order to hasten the test results and provide for a factor of safety. With this view the apparatus shown in Fig. 4 was designed. It consists of a rectangular frame driven by a motor to and fro' in such a way that the cords are slatted as the frame oscillates. Ten wires can be tested simultaneously. Each is attached to its own battery by the terminal provided, and the other end fastened to the frame at a point 24 in. above. Since the cord is 36 in. long, sufficient slack is provided to allow the frame oscillations. The frame was swung 92 times a minute through a vertical angle of 50 deg., and additional friction was provided by making the cord move between horizontal guide bars spaced 2½ in. apart. These are shown *in situ* in Fig. 5. The method of action was to operate the motor until the cord system open-circuited, or in the case of the more trustworthy cords, till the resistance increased to 10 times the original value. To detect the injured or weak cord, it was sufficient to shunt each cord across a miniature bulb and to connect all the cords in series. In this series a small bulb with a resistance 10 times the normal resistance of one cord is shunted. When current is passed through this comparison bulb and the ten cords in series, the shunted lamps glow in proportion to the resistance across which they are shunted. "Therefore the bulb of any cord whose resistance had increased to 10 times the normal glowed as brightly as the comparison bulb, and conversely any cord whose bulb was less brilliant than the comparison bulb had not reached the maximum resistance allowable."

In no direction has the work of the Bureau met with higher reward than in securing greater efficiency in the wire attachments and accessories of these mining lamps. This success could not have been attained without a generous and loyal response on the part of the manufacturers. Co-operation between theoretical and constructive science is seen at its best, and the miners reap the benefit. The great annoyance of unexpected failure of the light has been removed, the cost of upkeep has been diminished, confidence in the reliability of the illumination has been enhanced. When the test began no lamp cord manufactured could outlast 30,000 oscillations of the machine. So greatly has the manufacture of electrical conductors improved, that of the cords recently examined, one sustained more than 1,000,000 operations, three exceeded 200,000, and two 100,000 of these abrupt jerks. The Bureau is justified in saying that the problem of the mining lamp-cord has been satisfactorily solved.

Efforts to improve the character and availability of the illumination have met with equal success. The light intensity and method of distribution, factors on which the practical value of the lamp depends, have been so increased in efficiency that the standard of excellence now attained is very high. Practicability is as important as safety, for, as already pointed out, it is manifestly futile for the Bureau to urge the adoption of an impracticable device, however many or thorough the safeguards that surround it. The hope and ambition were encouraged that a lamp would be produced that would recommend itself, not only on account of its increased safety, but also by reason of its illuminating qualities, foremost among which may be included a wide angle of the emitted stream of light, with uniform distribution over the lighted surface. The intensity and light flux of a standard safety lamp were regarded as the minimum that could be tolerated in an electric lamp, but it was hoped that this limit would be exceeded. This hope has been realised. The safety lamp at its best is capable of giving about 3 lumens, while in the approved mining lamps this amount has been increased to 5·3 lumens. This intensity is not great, but it is sufficient, if distributed evenly over the surface. Uneven distribution operates injuriously, because the more brilliantly illuminated portions induce the pupil of the eye to contract, increasing the difficulty of seeing the more feebly illuminated parts. The lamp reflector is the piece of apparatus most immediately concerned in promoting uniform scattering of light. Highly polished reflectors, though more effective than dull surfaces, must be excluded, because they give rise to highly contracted areas of bright and faint illumination. The figure of the reflecting surface as well as the material of which it is made have to be determined with care in order to prevent undue concentration of light. By the action of the Bureau reflectors are now on the market that meet every requirement. The certificate of approval guarantees that in a critical 7-ft. circle, implying a cone of light having an angle of 130 deg., there are no black spots, and further attests that the average illumination in foot-candles on the best illuminated one-tenth of the diameter is not more than three times the average illumination throughout the diameter, and for at least 40 per cent. of the diameter the illumination is not less than the average.

The photometric arrangements necessary to determine the attainment of these results are not simple owing to the number and nature of the variables. The bulb, the reflecter, the battery, are constantly varying, and if these are treated as constant at any moment, the calculated candle-power and light flux depend more or less on arbitrary methods in the use of the photometer employed. The method adopted of comparing the performance of any piece of apparatus with the average performance of a large number of similar pieces affords a fairly trustworthy criterion. As an example of thoroughness, we may quote the method applied to bulbs, where the plan adopted was to require the manufacturer to deposit 1,000 specimens from which 100 were selected at random, and the current consumption and the candle-power of each were compared with the average of the whole, to determine the degree of uniformity attained. In this case especial care was necessary, since the length of life decreases as the efficiency increases, and the aim is to secure a bulb in which the efficiency is accurately adjusted to the length of life. It may be said here, that for months the lamp manufacturers could not obtain suitable bulbs of American design, but methods have now been adopted that already ensure a gratifying degree of uniformity and promise further improvement.

The method selected for measuring the candle-power over the whole surface illuminated by the lamp is indicated in Fig. 6 where the full assembly of the headpiece is shown. The apparatus can be rotated around the axis that coincides with the axis of symmetry of the cone of light. The readings of the photometer are taken at every 2½ deg. from the central position until the light becomes invisible. In this way an accurate value of the average candle-power can be obtained. Also the readings show the smoothness of distribution, while the presence of shadows or of areas of contrasted illumination can be easily detected by the eye.

The Bureau is to be congratulated on having accomplished a work of great national importance with distinguished success. It is true that the certificates granted refer to types or classes, rather than to individual lamps. But the tests demonstrate that it is possible to supply a lamp which meets all reasonable requirements. Trade competition can be safely trusted to ensure the maintenance of the standard set. When tests were first instituted deficiencies of construction or evidence of inferior design could be easily detected in all lamps submitted for examination. It is not too much to say, that all shortcomings of whatever kind have been rendered innocuous and in many cases completely eliminated, while mechanical ingenuity combined with theoretical development has introduced many new improvements that increase the economic values of the portable mining lamp. We may confidently expect that the disease of miners' nystagmus will be decreased by the use of a lamp giving improved illumination under conditions that do not demand excessive accommodation of the eye muscles.

THE SCIOTOVILLE BRIDGE.

By FRANK W. SKINNER, M.Am.Soc.C.E.

(*Concluded from page* 390.)

The Creeper Traveller.—The creeper traveller, of which a photographic view is given in Fig. 34, Plate XLV, consisted of a steel girder platform about 40 ft. square, with trussed horizontal steel outriggers, that increased the maximum width to about 67 ft. On this platform were installed two 51½-ft. derrick booms with a capacity of 50 tons each.

The traveller platform had a framework of heavy plate girders, and it and the outriggers were provided with a solid working floor, on which were installed two three-drum electric hoisting engines. The main booms were movable horizontally and vertically, and their topping lifts were connected to steel A-frames pivoted to the girder platform so as to maintain a vertical position when the traveller wheel base was on an incline. The arrangement described is clearly shown by Figs. 35 to 40 on Plate XLV.

The outriggers were extended 31½ ft. in advance of the working platform, and their extremities were guyed to the top of the creeper. The derrick booms were rigged with hoisting tackles made with 13 parts of ¾-in. steel cable, and handled maximum total loads of 100,000 lb. The topping lifts, proportioned for a maximum stress of 161,000 lb., were made with 19-part tackles rove with ⅞-in. plough-steel cable.

The booms were designed for a maximum stress of 210,000 lb., developed by lifting a 50-ton load at 37-ft. radius and developing a maximum unit stress of 13,200 lb. per square inch. The booms were calculated for loads of 50 tons at 37 ft. radius, 17 tons with 49 ft., 44 tons at 40 ft., plus an allowance of 3 tons for the rigging. They were intended to swing 10 ft. 4 in. transversely when loaded. The outriggers were proportioned for live loads of 150,000 lb. at the extremities. The A-frames were proportioned for a maximum reaction of 82,300 lb. at the foot of each post. The traveller was built to standard bridge specifications with unit stresses of 16,000 lb. in tension, and compression $16{,}000 - 70\,\frac{l}{\gamma}$.

Figs. 41 to 48, on Plate XLV, show diagrammatically the stresses due to different loads.

The traveller was supported, when in transit, on four pairs of double flange wheels running on tracks of 2-ft. 10-in. gauge, with the rails over the centres of the web of the top chords. When in service the traveller was anchored securely to the truss and the bearings were removed from the forward wheels by the operation of pairs of jack-screws (see Fig. 35) permanently attached to the girder framework and engaging cast steel blocks seated on the chords.

The tops of the A-frames were provided with long 7-in. gudgeons at the top and bottom bearings. At the top these pins engaged the goosenecks from the tower and between the jaws of the gooseneck the pin passed through a solid steel casting, that served as a sleeve, with a horizontal hole bored to take a pin engaging the riveted frame for the tandem sheaves of the topping lift. The mast was seated in a steel casting with a spherical bearing on a bottom casting bolted to the framework of the traveller. The constructive details are shown by

Figs. 35 to 40, on Plate XLV, and by Figs. 49 to 57, on page 460.

The traveller was equipped with two three-drum, 100-h.p. electric hoists weighing 18 tons each. The total weight of traveller and equipment was about 200 tons, and it was operated by an average force of 20 men. The greatest record was the erection of 300 tons of material in 9 working hours.

Counterweight and Anchorage of Creeper Traveller.—In order to resist the moment of the boom and outrigger loads, the traveller when in service was anchored to the top chords of the completed trusses by yokes engaging the chords and the framework of the traveller platform. Each yoke consisted, as shown in Fig. 38, of a pair of top and bottom channels, and two vertical bars connecting them, the lower ends of the eyebars engaging pins in the bottom channels and the upper ends having adjustment nuts set to bearing on the top flanges of the channels. When the traveller was advanced the eyebars on the inner sides of the chords were disconnected from the lower channels, and their lower ends were elevated and fastened in position to clear the system of lateral bracing, while the lower channels, pivoted about the pins through the outer I-bars, were dropped to a vertical position and held there while the traveller advanced.

In moving along the top chords from U–18 to U–14, the traveller descended a considerable grade, and in order to prevent the possibility of it sliding down the slope out of control it was balanced by a counterweight suspended from the top of the main post at U–20. This counterweight was a little heavier than was sufficient to overcome the tendency of the traveller to move downward, and although not necessarily required when the traveller was seated on the horizontal portion of the top chord, it was still used under these conditions, where it acted as an additional safeguard to prevent the possibility of any accidental movement on the traveller beyond the finished portion of the cantilever track.

The counterweights consisted of a pair of steel transverse horizontal girders connected by cross-frames and supporting 20,000 lb. of rails. The counterweight-box extended across the full width of the bridge, and was supported at each end by a single part of ¾-in. plowed steel cable with a strength of 44,000 lb. and a factor of safety of 4.6. The standing part of the cable was securely clamped to the free end a short distance from the extremity, and the bight thus formed engaged a sheave shackled to the end of the box. The standing part continued vertically upward over a fixed sheave at U–20 and was rove in a tackle attached to the rear of the creeper traveller. The line was led continuously from the tackle across the bridge and rove through a corresponding tackle in the plane of the other truss, the free end being similarly continued over a fixed sheave at U–20 and down to engagement with the counterweight-box. The rear end of the traveller was made fast by eyebars connected with the trusses when in service.

Manilla tackles were also attached to the ends of the counterweight-box and to the trusses at U–20, and their lead lines were run to the hoisting engines on the traveller. The counterweight could be raised or lowered by operating these tackles which, of course, were made fast when the traveller was stationary.

When the traveller was to be advanced the counterweight was lowered by the hoisting engine slacking off on the Manilla tackles, and the free ends of the steel cables were unclamped where they formed the bight engaging the counterweight connection, and were allowed to overhaul as the box was lowered by the engine until the required position was reached, when they were again clamped tight and the Manilla tackles slacked off enough to throw the weight on the steel cables again. The traveller was then advanced by the hoisting engines winding up on rope tackles. This was easy since only the unbalanced part of the counterweight had to be lifted.

Jigger Bridges.—These two bridges each consisted of two plate girders about 40 ft. long and 9 ft. 8 in. apart, on centres, fulcrumed on, and projecting 17 ft. 3 in. beyond, the last erected floor beam. The cantilever portion had a floor of transverse I-beams about 2 ft. apart decked over with 1-in. boards and carrying the track rails. The rear extremity was anchored to the top flanges of the permanent floor stringers by pairs of heavy hooks. These bridges were moved forward as soon as convenient after the floor steel was set under them. They were a great help in erection, as they enabled the bridge steel to be brought out under the traveller booms, clear of the bridge bracing.

Work on the masonry substructure and foundations was commenced in November, 1914, the erection of the steel superstructure was commenced early in 1916 and was completed July 31, 1917. The erection of the steel superstructure was only slightly interrupted by bad weather during the winter months.

THE IRON CARBON EQUILIBRIUM DIAGRAM AND ITS PRACTICAL USEFULNESS.*

By Professor H. C. H. CARPENTER, M.A., A.R.S.M., M.I.M.M. (Royal School of Mines.)

(*Concluded from page* 427.)

I. ANNEALING.

LET us make a beginning with the operation known as annealing, which has an immensely wide range of applications. So far as steels are concerned annealing has for its purpose any or all of the following aims: (1) The softening of the material so as to make it suitable for machining or conform to certain specifications; (2) the removal of internal stresses or strains due to previous hardening operations; (3) the "refining" of the steel crystals which confers beneficial properties.

The manner in which the steel is treated is of profound importance in its effect on the results of annealing, and is deserving of a special exposition. Within the limits of this paper, however, it is impossible to attempt this, and I must content myself with referring to D. K. Bullen's "Steel and its Heat Treatment," where the matter is admirably discussed. On this point he says (page 40): "The manner in which the steel is placed in the furnace is a factor of supreme importance. It may even be said that three different kinds of annealing may be produced in the same furnace operating at the same indicated pyrometer reading dependent simply on the method of placing the stock in the furnace. Particular stress should be laid upon the necessity for getting heat to the centre and bottom of the charge, not only for the sake of the uniform annealing but also to shorten the time of absorption and lessen the time of exposing the top and outside edges of the charge to the heat and influences of the chamber atmosphere. Thus it has been shown that a uniform chamber temperature does not necessarily mean a uniformly annealed product; that a circulation of heat through the mass is more desirable than the mere application of heat from the outside. It is advisable to raise the charge above the furnace floor or hearth upon suitable blocks or supports, to separate each piece from the other, and to avoid localised heating through overloading. It is only by such means that there will be provided an opportunity for the circulation of the gases through the charge. Slow, careful and uniform heating is always advisable regardless of the chemical composition or physical condition of the steels. Heating to such temperatures as are common in general annealing practice necessarily results in more or less change of physical condition or molecular readjustment, and the greater the hardness, brittleness and amount of internal strain in the metal, the greater will be the deleterious effect of such heating. Thus objects of intricate design, or with varying cross-sections, or steel in a hard and brittle condition, should be given the greatest care in heating, in order that the release of strains should not cause warpage or otherwise injure the metal. Such pieces should never be placed directly in a hot furnace, but should be given a careful preheating."

The Annealing of Steels with less than 0·9 per cent of Carbon.—The changes of microscopic structure and of phases when these steels are heated from the ordinary temperature up to the melting range have already been described. But there is one point of vital practical importance, particularly in relation to mild low-carbon steels, which now requires to be explained. On passing above the line G O S, which we may call the upper transformation line, the steel becomes homogeneous austenite. If in the case of any given alloy the temperature of the line is not greatly exceeded, *e.g.*, by not more than 50 deg. C., and if the steel be thereafter cooled to the ordinary temperature, whatever may have been the previous size of the crystals or grains, as they are also called, the resulting crystals will be very small. In other words, the steel as a whole will have been refined. Below the line G O S this does not occur. The explanation is as follows: The crystals of homogeneous austenite formed just above G O S are small, and unless they are maintained there for a long time they do not grow appreciably. On cooling the crystals of ferrite and pearlite formed from them are also very small. This refining effect is shown very strikingly in photograph No. 24, page 454, which I owe to the kindness of Dr. Stead, and which requires no explanation other than that he took some coarsely crystalline soft steel and heated one end to just above 1,000 deg. C. On the other hand, if the temperature of the austenite is raised much above that of the line G O S, a coarsening of the structure sets in which is roughly proportional to the temperature reached and the time that the steel is kept there. This refining of the steel has a most beneficial effect on its properties, and results in the production of a material which, for a given composition, has the greatest tenacity combined with sufficient ductility of which the steel is capable.

As, however, the temperature above G O S is exceeded, a weakening of the tenacity becomes apparent, even although for a time the ductility may be improved. We thus have in the refining effect a most valuable means not only of getting the best out of a good steel, but, what is almost more important, of restoring to its original properties a steel which may have become very brittle or very weak owing to a number of causes which will now be enumerated.

1. There is a form of brittleness to which very soft steels are liable if they are held for any considerable period at about 600 deg. C. This has been investigated very carefully by Dr. Stead, and is sometimes known as Stead's brittleness. Owing to the fact that the steel contains very little carbide and that at this temperature this tends to leave patches of pearlite and segregate as islets of cementite, the material consists almost wholly of ferrite; in other words, this may be regarded as a property of iron rather than steel and, in fact, is strictly confined to very mild steels. These materials are sometimes worked at temperatures of about 600 deg. C., and they develop a remarkable coarsening of grain size, with which the above-mentioned brittleness is associated.

2. Mild steels, but not necessarily as low in carbon as the previous, are liable to produce great coarseness of structure due to the formation of large grains in the operation which is usually called "close-annealing." These temperatures are in the neighbourhood of 800 deg. C., that is, in the area G M O, where the phases present are B iron and austenite. This large grain size is frequently associated with brittleness or, at any rate, weakness.

3. At much higher temperatures, where the steel is composed exclusively of austenite, and in such operations, for instance, as the flanging of a mild steel plate, overheating of the material frequently occurs, coarse crystals are developed, and again brittleness or weakness results. In this case I am not including materials in which the temperature reached is so high that the solidus line A E is passed and an actual incipient liquefaction of the steel takes place. About this I shall have a word or two to say shortly.

In the three previous cases, however, that is to say whether the brittleness or weakness has been developed below, within, or above the critical ranges, and provide that the composition of the steel has not been substantially altered by oxidation, it is possible by the above refining treatment to restore the steel almost, if not wholly, to its original good mechanical condition. It is thus clear that the line G O S in the diagram, far from being of purely scientific interest is of the utmost practical moment, and, in fact that this characteristic property which steel possesses of being refined, is capable of being turned to most valuable practical uses.

A few words now as to the temperatures to which the steels whose compositions vary from 0 per cent. to 0·9 per cent. carbon should be heated in order to obtain the best mechanical results by refining. Reduced to its simplest terms, this annealing operation requires the production of an entirely new crystalline structure, the constituents of which shall be of the smallest grain size possible, and from which all internal stresses and strains have been eliminated. The most suitable temperature in any given case can conveniently be related to the carbon percentage in the steel, and the following table contains the recommendations of the American Society for Testing Materials with regard to this.

Range of Carbon Content. Per Cent.	Range of Annealing Temperature. Deg. C.
Less than 0·12	875 to 925
From 0·12 to 0·29	840 to 870
From 0·30 to 0·49	815 to 840
From 0·50 to 0·90	790 to 815

As regards the length of heating, this depends on the size of the object, and must be sufficient to enable the whole mass of the steel to be uniformly heated. With regard to cooling, it is important that this should be at the right rate. In certain cases it might be necessary to chill the steel in, for instance, a bath of oil or water, and in this case the new grain size and rearrangement of structure would be maintained. In other cases an air cooling might be desirable; this, while not constituting so rapid a method of chilling, would be sufficiently fast to prevent a coarsening of the structure liable to be produced by slow cooling in the furnace through the transformation ranges. In passing through these the ferrite, which begins to deposit below the line G O S either forms a network first round the austenite, and then round the pearlite grains, or else coalesces into irregularly-shaped masses. A moderately slow rate of cooling develops the network structure, while a very slow rate of cooling breaks it up and gives time for the coalescence of the ferrite. Such slow rates of cooling must therefore be avoided in all cases where a refining of structure is desired. Moreover, air cooling has another important effect in determining the way in which the ferrite and cementite separate from the austenite.

A word of caution is necessary, however, in the first place. Thin objects and those containing high carbon must not be so rapidly cooled as thick specimens and those containing low carbon, otherwise their ductility is impaired. With regard to this the American Society for Testing Materials recommends as follows: Thick objects with less than 0·50 per cent. carbon may be

* Paper read at the Spring meetings of the fifty-ninth session of the Institute of Naval Architects, March 21, 1918.

cooled completely in air, of course protected from rain or snow. Objects with 0·50 per cent. carbon or more and thin objects with 0·30 per cent. to 0·50 per cent, carbon, may be cooled in air if their cooling is somewhat retarded, as, for instance, massing them together, as happens in the case of rails. Under these conditions air cooling gives great strength and high elastic limit, but somewhat at the expense of ductility. This air cooling generally gives the ferrite-cementite complex not in the form of lamellar or well-defined pearlite, but in the microscopically irresoluble state known as sorbite, which always confers great mechanical strength on the steel. There is, however, one type of brittleness (it is very liable to occur with mild steel) which cannot be removed by the refining-annealing, or indeed any other form of heat treatment. This occurs in what is called "burnt steel." This material is cold—short and brittle, with a coarse and even a flaky crystalline fracture. It has a low tensile strength, and requires the greatest care in forging and welding.

In contrast to steel which has been merely overheated, steel which has been burnt has been heated to such a high temperature that it has partially liquefied; in other words, the solidus line A E has been passed. What happens in this case is that the liquid which forms round the crystals is much richer in carbon. If this were all that happened it would be possible to restore such a steel to its original condition by an appropriate heat treatment. But what appears also to happen is that this liquid tends to pass through the intercrystalline cavities in the metal and to collect in small pools in some of the larger of these cavities. Moreover, the surface of the steel nearly always presents a blistered appearance, due to the escape of gas caused by the reaction between the oxygen of the air and the carbon of the steel, so that there is nearly always some oxidation in the surface layers. These two facts—the segregation of highly carburised areas and an alteration in the surface layers—make it impossible to restore by any heat treatment such steel to its original properties. It must, however, be said that burnt steel indicates great carelessness in heat treatment, and there is no reason why with proper care it should ever occur. A photograph of some of the highly carburised pools of liquid is shown on page 454, No. 23.

THE ANNEALING OF STEELS CONTAINING MORE THAN 0·90 PER CENT. CARBON. HYPER-EUTECTOID STEELS.

These steels, containing as they do between 0·9 per cent. and about 1·5 per cent. carbon, comprise the very important class of industrial steels known as tool steels. There are two transformation points in the solid material, one along the line S K where the a ferrite and cementite form austenite, and the other along the line S E where the excess of cementite dissolves to form homogeneous austenite. But on account of the relatively small proportion of free cementite in such steels, and also because on heating above the line S E there is a large increase in grain size, the majority of annealing operations are more intimately connected with the change at S K. The objects of annealing in these high carbon steels are similar to those in the case of the low carbon steels (1) The removal of internal strains and stresses set up by previous operations; (2) the softening of the steel so as to convert it into the form most suitable for machining; (3) the refining of the structure. The first two objects can be realised by a reheating at a temperature below S K, namely, from about 675 deg. to 700 deg. C.; the third, however, is more difficult to achieve since the form in which the excess of cementite may exist is one of the governing factors.

For refining the grain of these steels, it is necessary to heat to a temperature rather above the line S K. If the steel has a carbon percentage only slightly above 0·9, heating to about 750 deg. to 780 deg. C. will be sufficient. Such a treatment will give the finest grain size attainable by annealing. And even if the carbon content is considerably above that of the eutectoid ratio the annealing may still be done at about the same temperatures, provided that, as is frequently the case, the pearlite is in the sorbitic condition, in which case the excess of cementite is usually dissolved in it. Sometimes, however, these steels contain the excess of cementite well segregated either as a network round the crystals of pearlite or in the form of spines. Such a structure means that the steel is difficult to machine on account of the great hardness of the cementite. Annealing just above the S K line does not alter this cementite; it simply refines the pearlite. In such a case two operations are necessary: (1) The steel must be heated above the line S E and then quickly cooled, an operation which retains the cementite in solution; (2) in this condition it must then be heated for a short time to about 750 deg. C.; this, while refining the grain size and softening the steel as a whole, does not reprecipitate the cementite, provided it is of short duration. The second operation may be modified by only carrying the reheating to a point rather below S K. This, while not refining the steel, at any rate ensures that the excess of cementite is not reprecipitated either as spines or a network. What happens is that it comes out in the form of little nodules or spheroids distributed tolerably evenly through the steel. This spherical condition of the cementite renders the machining of high carbon steels very much easier.

II. HARDENING.

The fact that high carbon steels can be hardened by a certain heat treatment is probably the most important property of any metal or alloy with which we are acquainted. It lies at the very foundation of all engineering operations where machining is involved. And it is in regard to this that if the best results are to be got out of any tool the utmost attention must be paid to the evidence afforded by the equilibrium diagram. The operation of hardening tool steel involves two factors; firstly, a condition obtained on heating, and, secondly, the retention of that condition as far as possible on cooling. It is therefore on the whole a more highly skilled art than that of annealing, where the rate of cooling is of somewhat less importance.

No matter how long a tool steel is heated below the line L S K, and how rapidly it is quenched in water no hardening will take place; the steel requires to be heated above that line and rapidly chilled in order to prevent the A1 inversion taking place and to produce a hardened tool. The hardening operation, therefore, requires that the steel shall be transformed into a condition corresponding to a part of the diagram above L S K, and as far as possible retained in that condition by chilling. It will be seen, therefore, that the utmost attention must be paid to the evidence afforded by the lines S K and S E over the range 0·9 per cent. to 1·3 per cent. carbon, which includes most of the tool steels. As already mentioned, austenite, as represented by homogeneous polyhedral crystals, is never obtained completely in pure iron carbon steels, even with the most rapid chilling from the range in which it is stable. Under these conditions the so-called martensite, with a pronounced acicular structure which hides the polygonal crystals, is the chief constituent obtained. This characteristic structure is due to the strains set up in the austenite by the stresses produced by rapid chilling. As already mentioned, if the rate of chilling is somewhat slower, troostite is obtained; if it is slower still, sorbite results. All tool steels in the hardened and subsequently tempered or toughened condition contain their carbon in the form of one or more of these constituents.

Iron carbon tool steel is usually hardened at temperatures between 25 deg. and 50 deg. C. above the line L S K. This gives the best refinement and the maximum hardening effect. It must be emphasised that heating for hardening requires much more care than heating for

× 100

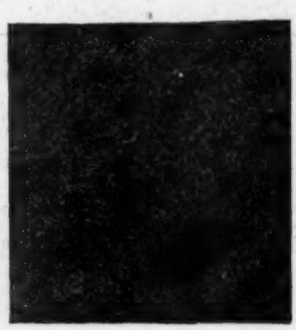
No. 13.—Eutectoid steel quenched from 730° C., consisting wholly of martensite (altered austenite).

× 350

No. 14.—The same as No. 13 more highly magnified.

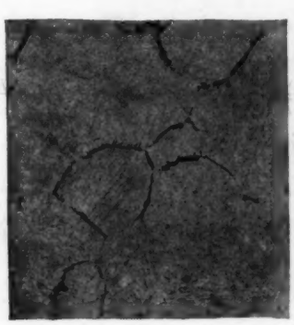
× 350

No. 15.—Eutectoid steel quenched from 1,100° C., consisting wholly of martensite.



× 100

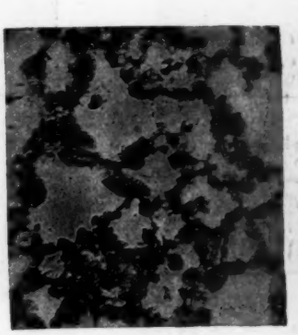
No. 16.—The same steel quenched from 1,400° C. and afterwards heated to 400° C. It shows the martensite passing into troostite (dark) and sorbite.



× 100

No. 17.—Steel containing 1·1 per cent. of carbon quenched from 950° C. It shows

(1) Crystals of martensite and
(2) Dark cell walls of troostite.



× 100

No. 18.—The same steel as No. 17.

(1) White areas ... martensite.
(2) Dark cell walls ... troostite.

× 100

No. 19.—Steel containing 1·25 per cent. of carbon (tool steel). Annealed.

White cell walls ... cementite.
Dark patches ... ... pearlite.

× 100

No. 20.—The same steel as No. 19 quenched from 780° C. It shows

(1) Dark area of martensite and
(2) White cell walls of unabsorbed cementite.

annealing; the latter is nearly always followed by a slow or moderate rate of cooling and the relief of stresses and strains; the former is followed by the severest test to which any steel can be put, namely, very rapid chilling accompanied by the setting up of stresses and strains in it. Speaking generally, it may be said that the heating for hardening must be slow, uniform and thorough, and at the lowest temperature which will give the desired results. If the steel is not uniformly heated, neither will it uniformly cool in the quenching bath, and this is the most frequent cause of the generation of hardening cracks.

In many cases the temperature of the line S E is not exceeded in heating for hardening. This is done deliberately; it would no doubt be advantageous to get the whole of the excess cementite into solution before quenching, but owing to the fact that S E rises steeply, it will be obvious that the temperature necessary to produce this rises steeply also with increasing carbon content. This means that the austenite grains grow rapidly and that the refining of the steel is destroyed; moreover, the higher the temperature from which the steel is quenched, the greater will be the stresses and strains set up in the material. Consequently in hardening high carbon tool steel some of the cementite exists undisturbed in the austenite at the moment of quenching, and is therefore retained at the ordinary temperature. It is, however, as has been mentioned, a very hard constituent, and it contributes, therefore, to the hardness of the hardened tool.

As regards the actual medium in which the tool is heated, great stress must be laid on the importance of ensuring that as far as possible no alteration occurs in the composition of the steel. Formerly tools were heated for hardening in furnaces which, however carefully the steel was protected, permitted some surface decarburisation. This had a very important effect in that it meant that the steel was not homogeneous, and the proper hardening temperature for the interior would not be the proper hardening temperature for the surface. The lead baths which were introduced as an improvement suffered from various drawbacks, and there is no doubt that to-day the best results are obtained by the use of baths of molten salts, such as, for instance, the chlorides of sodium and potassium. Their low specific gravity permits of a more active circulation of the heating liquid; there is little or no vaporisation, and the steel when removed for quenching is covered with a thin protective layer of salt. With careful temperature regulation of these baths, overheating of the steel can be entirely prevented. For the so-called alloy tool steels, where higher temperatures are required, barium chloride is more suitable than the chlorides of sodium and potassium. As regards the quenching medium, attention must be paid to the specific heat, conductivity, viscosity and volatility of the liquid; all of these affect the rate of cooling, and by obtaining the most suitable combination in any given case the desired effect may be obtained.

III. Tempering and Toughening.

If the tool has been quenched under proper conditions in a medium such as water, when the rate of cooling will have been very rapid, it is obtained in a hard, brittle, highly stressed condition. In this state it is so brittle that, except in a few cases, it will be impossible to use it for machining purposes.

Tempering, which follows the hardening operation has two objects: Firstly, the diminution, if not the entire removal, of the quenching stresses; and, secondly, the incipient precipitation of troostite from the stressed austenite (martensite). If the steel has been effectively quenched, the formation of troostite begins at about 200 deg. C. Provided the temperature does not reach 400 deg. C., the great bulk of the steel will in this way be transformed into troostite, and the higher the tempering temperature the more complete the removal of stress and the transformation into troostite. These temperatures are usually judged by heating in air, when the so-called "temper" colours, which are really oxidation tints, are produced. These begin with faint yellow, and pass through various stages in which straw, dark yellow, brown-yellow, brown, purple, light blue, and dark blue figure. These are a very useful practical indication of the extent to which the tempering has produced, and the precise degree desired in any given case can thus be attained.

For many purposes, then, the tool steel which has been hardened and afterwards tempered so as to be ready for practical work consists chiefly of troostite. There may, however, be cases in which it is necessary to carry the softening still further and to produce sorbite. This may be called toughening. The transition from troostite to sorbite is gradual, and the temperature at which it begins depends to some extent on the composition of the steel and the extent to which it has been hardened. But, broadly speaking, it may be said to begin at about 400 deg. C., and to continue at the expense of the troostite up to about 600 deg. C. In this condition the steel has very important mechanical properties, owing to the influence of the sorbite. It is rather less ductile than a steel of the same composition whose carbon is in the form of pearlite, but it has a very decidedly higher elastic limit and tenacity, properties which frequently find practical application. Rather under the line L S K the sorbite passes into, not the banded or lamellar variety of pearlite, but a beaded or granular form.

Tempered and toughened steels therefore require to be produced in certain temperature ranges, which are lower than the L S K line in the diagram; and the reason why there are no areas in the diagram to indicate the limits of their existence is that constitutionally they are the same as pearlite, although their physical characteristics are strikingly different.

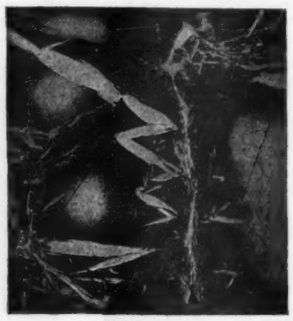
Both these constituents can be obtained in another way, namely, by adopting a less rapid rate of chilling from the hardening temperature, a rate which is insufficient to arrest the steel in the martensite condition, and allows it to pass on to the troostitic or sorbitic condition, as the case may be. This method has two obvious advantages: (1) It substitutes one operation for two, and (2) it does not subject the steel to such severe stresses in quenching, and therefore the risks of quenching cracks appearing are lessened. Hence the use of various oils as quenching media which permit of these retarded coolings.

IV. Temperatures of Hot Rolling.

Insufficient attention has been paid to this subject in spite of its important influence on the mechanical properties of the finished product. Let me illustrate the matter by reference to the rolling of steel rails, particularly in regard to the finishing temperatures, as to which important data are contained in Technologic Paper No. 38 of the American Bureau of Standards. But what follows applies equally well *pari passu* to the types of steel in which naval architects are more directly interested, particularly the mild varieties which are so much used in ship constructional work.

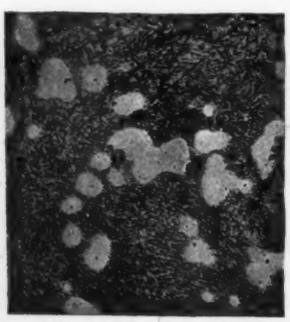
× 100

No. 21.—The same steel as No. 19 quenched from 1,100° C., showing homogeneous martensite.



× 100

No. 22.—Steel containing 0·90 per cent. of carbon heated *above* the solidus but below the liquidus. It shows unhomogeneous austenite and martensite.



× 100

No. 23.—The same steel as No. 22. The white areas were *liquid at* the moment of quenching.

Natural size.

No. 24.—It shows the refining of the steel crystals by heating above the transformation line G O S.

The undesirable effects of rolling either too hot or too cold have long been recognised, and have been stated many times by competent authorities in some such language as the following: "Rolling steel below the critical stage," *i.e.*, below the line L S K in the diagram, "distorts and weakens the crystalline structure, while rolling and finishing at too high temperatures above the critical range produces a coarsely grained steel which is weaker than the finer grained structure obtained by doing work continuously on the rail down to the critical range, which usually lies between 650 deg. and 750 deg. C. for rail steels and is rarely above 700 deg. C."*

Let us first consider in a general way the relation of the temperature of rolling to the micro-structure of the steel. The ingot, as it comes to the rolling mill, has its constituents present in the form of grains of austenite. The temperature is about 1,100 deg. C., and it will be obvious by reference to the diagram that whatever the composition—usually the carbon is about 0·5 per cent. —that is the constituent present. The effect of the various passes through the rolls is to crush and shatter these crystalline grains. At these temperatures the molecules of the austenite have considerable mobility. Consequently any distortion of the crystalline structure is quickly repaired, and the crystals begin to grow again until the next pass through the rolls repeats the deforming process. The later passes determine the size of the austenite crystals and subsequently the grain size of the finished product. The nearer the temperature of the later passes is to the upper limit of the critical range (line G O S), the smaller will be the austenite crystal and the final "grain size" of the steel. If the rolling is continued down into the critical range the microstructure of the finished rail will show this by the distortion of the ferrite which is precipitated in passing through this range. If it is carried much below the lower limit of the range (line L S K) both the ferrite and the pearlite crystals will record this fact. By this means a skilled microscopist can tell whether a rail has been finished above, within, or below the G O S L.

Of the 40 rails examined by Dr. Burgess every one was finished well above the line G O S. This was proved not only by measuring the temperatures in the rolling mill at the final pass through the rolls, but by the microscopic examinaton itself. The latter showed that the ferrite network outside the pearlite grain had in no case been distorted or broken up after being formed. Evidently rolling had been completed before any ferrite was deposited, *i.e.*, above G O S. And in nearly all cases the size of the pearlite grains indicated that rolling had been discontinued at temperatures well above this, so that the parent austenite had had time to re-orient itself after being distorted, and to grow to a fair size before any ferrite appeared.

Temperature measurements at the mills—experiments were made at four different ones—fully bear out these conclusions. Ingots were found to be rolled from an initial temperature of from 1,150 deg. to 1,075 deg. C. The rails were finished at temperatures which varied between 1,050 deg. and 880 deg. C., but usually within 50 deg. of 935 deg. C. These finishing temperatures were measured at the hot saws. Heating curves showed that the rails each had one well-marked transformation point at about 730 deg. C. and a transformation range from 690 deg. to 650 deg. C. on cooling. Taking a mean finishing temperature of 935 deg. C., this is no less than 270 deg. C. above the mean critical range at 665 deg. C. on cooling. This is not all, however. As the centre of the railhead (100-lb. section) was about 50 deg. C. hotter than that of the outside, it was finished at about 325 deg. C. above the critical range on cooling. All these rails could with advantage have had work done on them for another 250 deg. C. on cooling.

Manufacturers, of course, prefer to roll their rails hot. It means that less power is required to operate the mill and there is less wear and tear of the rolls. There can, however, be little doubt but that the consequence of

* Page 5 of Report No. 38.

this is that rails as rolled at present do not possess as good mechanical properties as they might on account of the high finishing temperature employed. In all cases a smaller grain size such as is produced by finishing at lower temperatures could with advantage be insisted upon. The decided improvement both in tenacity and ductility due to diminishing grain size is well shown in the table below given by Sauveur.*

What is required is a proper temperature control at the mill. With regard to this the American report says: "The problem appears to present no unusual difficulties from the pyrometric point of view, and can be solved satisfactorily in several ways, and if desired the temperature control may even be made automatic and continuous with only occasional supervision. What is desired is a measure of the actual temperature of each of the rail bars either as they emerge from the finishing pass, or perhaps better, if we assume a constant speed of rolling through the rail passes, a measure of the temperature of the blooms as they enter the rail mill. There may be some advantage in the latter procedure due to the fact that it permits holding a bloom if too hot before entering the rail passes and discarding a bloom that is too cold. . . . There are available at least two reliable and convenient methods based on the use of optical and total radiation pyrometers which permit an exact measure of the temperature of a hot rail in motion, and possessing the further great advantage of not requiring any contact with the rail. . . . It appears clear that if it be considered desirable to control the temperature of rails during their manufacture the problem may be easily and exactly solved by means of several types of optical and radiation pyrometer which have given excellent service in other technical fields and also with very small cost of installation and maintenance."

Grains per Square Inch.	Tenacity, Tons per Square Inch.	Percentage Elongation on 2 in.	Reduction of Area, per Cent.
44,000	44·2	15·0	20
54,000	44·7	19·0	22
104,000	50·0	22·5	35

These remarks apply with equal force to the rolling of the various other types of steel. In the case of mild steels, which are rolled in so many different shapes and sizes, the beneficial effect of rolling at the lowest temperatures consistent with the absence of anything that could be called cold work would, if possible, be even greater. In this case it would serve to break up the predominant partner—viz., a ferrite—i.e., the iron itself. To-day it is no more than true to say that the pyrometer and the microscope are not merely twin instruments of metallographic research, but are firmly established as aids in actual technical practice. The recent discussion at the Faraday Society disclosed the fact that one works alone in this country has some 600 pyrometers in actual use in the operating departments. To whatever metal or alloy they may be applied, they must, if the full value is to be got out of them, be used in strict conjunction with the equilibrium diagram. Together these constitute a metallurgical trinity of unequalled power and effectiveness.

I desire to acknowledge the valuable assistance of Miss C. F. Elam and Mr. C. C. Smith in preparing the photographs and illustrations which accompany this paper.

Steel Fusion Welds.—When steel is welded by the aid of the oxy-acetylene blowpipe or the electric arc, the heating is very local and the grains become coarser; this is particularly noticeable with arc-welding, in which heating and cooling are more rapid. On the grain boundaries cementite appears, sometimes pearlitic, and the microphotographical study of the welds also brings out other interesting peculiarities, to which Mr. S. W. Miller, proprietor of the Rochester Welding Works, drew attention in the February meeting of the American Institute of Mining Engineers. The paper was illustrated by a large number of photographs. When the welds are etched with picric acid, the cementite turns more or less brown; but some lines only become noticeable after prolonged boiling with picric acid or sodium picrate. In addition to the cementite spots, there are generally fine specks of oxide; the welding also seems to introduce gases, nitrogen and probably hydrogen, into the steel unless the welding rod—generally a low carbon wire of 0·1 per cent. or 0·18 per cent. of carbon—contain manganese or vanadium; these constituents have the disadvantage, however, that a slag is formed, which is not easily floated to the surface. The burning and agitation of the steel also lead to a change in and to heterogeneity in the carbon content. Electric welds (proper oxy-acetylene welds generally do not) further show the peculiar fine lines above-mentioned, which seem to represent the sides of diagonals of squares. They might mark the intersections of the faces of trapezohedrons and of cubes (Howe); they might also be Neumann lines, observed on corroding boiler plates; they might further not be lines, but cracks. But Miller found, that they darkened when boiled in sodium picrate, were more numerous with high-carbon wire than with low-carbon wire, and disappeared after heating the specimen above 750 deg. C. and then cooling at certain rates. On the other hand, the lines widened in steps on prolonged etching, which would be compatible with their being lines of incipient fracture along planes of cleavage.

* Sellen, "Steel Rails," page 424.

MAGNESITES AND MAGNESITE BRICKS.

At the ordinary monthly meeting of the Ceramic Society, held at Stoke-on-Trent on March 9, a paper bearing the title "*Magnesite and Magnesite Bricks*" was read by Mr. W. Donald, of Glasgow, the subject being discussed mainly from the manufacturer's point of view.

The magnesite used in this country for making bricks comes from Greece and India, but the material occurs also in many other countries, apart from the Austrian deposits which before the war formed the chief source of supply.

Density, porosity, tensile strength, resistance under load at high temperatures, and chemical composition of the bricks, all have an important bearing on the refractoriness, and control of these factors necessitates a full knowledge of the raw magnesite as regards mineral impurities and the effects of different kinds of heat treatment (different temperatures, different periods of heating, different rates of cooling, oxidising or reducing atmosphere, &c.) with or without the elimination of certain impurities or the addition of certain other materials. Detailed microscopic examination of both raw materials and finished products also gives information of great value, owing to the possibility of tracing the causes of physical changes.

After referring in considerable detail to the mode of occurrence of the Austrian and Hungarian magnesite deposits, and to the composition and characteristics of the materials and bricks, the author proceeds to deal in like manner with Greek magnesite. The latter has usually more silica and lime than Austrian magnesite, but much less ferric oxide. The impurities present in the Greek magnesite, particularly the oxide of iron and alumina, are very irregularly distributed through the finely crystalline mass of magnesium carbonate, and the difficulty of accomplishing a satisfactory calcination of the material throughout in a single firing is thus increased. The deposits of Canadian magnesite are more irregular still. The author believes that careful selection of the material would enable Greek magnesite to compare much more favourably as regards silica and lime content, with Austrian magnesite.

In sections of Greek magnesite bricks fired at 1,750 deg. C. and 1,850 deg. C., the faces of the bricks nearest the heat were quite fused; half an inch from that face the structure showed a change from small to large crystals, but no bad effect of heat was observed where large crystals had been formed. Similar sections of Austrian bricks showed no indication of having been fired at a high temperature. In the Austrian bricks the magma is fairly uniformly distributed through the whole brick, and is seen to have inter-penetrated each particle. The magma in British-made Greek bricks is not so evenly distributed, but after spalling repeatedly the exposed face often shows evidence of frothing with great porosity, caused by the impurities present in the magma. The magnesian silicates present are bulky and very viscous, and though they melt at 1,550 deg. C., they must be almost immovable as a molten liquid even at 1,650 deg. C. Hence ferrous iron should be introduced (Austrian magnesite, it may be remembered, has ferrous carbonate very evenly distributed through the mass).

Dr. A. Scott has shown that magnesia compounds and lime compounds have melting-points ranging between 1,500 deg. C. and 1,550 deg. C., and any compounds in which both the magnesia and the lime are included have melting-points 150 deg. C. (or more) lower. Lime should, therefore, be removed as far as possible, and the lime present, as well as the other impurities, should be distributed as evenly as possible, for which it is necessary that the consistency of the magma formed should not be such as to hinder the distribution.

From the steelmakers' point of view the results now obtained with British-made bricks used in basic open-hearth furnaces, pig-iron mixers, Talbot furnaces, and electric furnaces are on the whole satisfactory. Difficulties are still being experienced from spalling, from inability of the bricks to withstand the corrosive action of basic slag, and from inability to stand the great strain in the roofs of electric furnaces. In one electric furnace, with Greek magnesite bricks, for the same life of magnesite lining which formerly gave 120 heats with Austrian (Spaeter) bricks, 75 heats are now obtained. In another electric furnace the Greek bricks in the side walls show frothing and porosity caused by the action of the molten steel and the basic slag, which the Austrian bricks formerly used had withstood successfully. In still another electric furnace good results in the roof are obtained even with furnace hands of less experience than those now available.

Generally speaking, the magnesite bricks on the market belong to two main types; one type is made from finely-ground material, and the bricks weigh about 72 cwt. to 76 cwt. (sometimes to 80 cwt.) per thousand; the other type is made from less finely-ground material, and the bricks weigh 82 cwt. to 86 cwt. (sometimes to 88 cwt.) per thousand. Sections of the former type show finer particles, and on the whole a more complex colour scheme; the latter show in sections greater light and shade between particles and magma, and also between the different particles. These characteristics were shown with the aid of a lantern, as were also the structure of particles and the distribution of both particles and magma in different bricks. Sections of raw and calcined magnesite were also shown, and by comparison with the latter, it was made evident that a large proportion of particles in British-made bricks remains in the state of calcined magnesite, and that the impurities surround the particles, rather than inter-penetrate as in the Austrian products.

Sections of Indian and Greek magnesites calcined at about 1,250 deg. C. showed minute granular forms. Indian magnesite calcined in an electric furnace at 1,750 deg. C. showed alteration, which was greatest immediately about impurity. Electrically-calcined Greek magnesite (at about 1,900 deg. C.) showed the particles completely altered about the impurity and for some distance round. Greek magnesite after prolonged calcination at a lower temperature in a modern shaft kiln under reducing conditions showed that the change of mineral particle extended practically throughout the mass. The massive crystalline appearance now in the Greek magnesite, even where there is no coloration, resembles the lighter portions of Austrian bricks. Some difference still exists, but the author firmly believes that the minute magnesite crystals in the raw Greek magnesite could be converted in the economical course of manufacture into the kind of crystalline material naturally present in the Austrian bricks. The author feels sure the Austrians now calcine the magnesite in rotary kilns, though shaft kilns were used originally, but he thinks there would be great difficulties in using rotary kilns under proper conditions for calcining a suitable mixture of Greek magnesite and ferrous carbonates. He believes the modern gas-fired shaft kiln can best answer the purpose of magnesite brick-makers who use raw materials in the crypto-crystalline state. There are modern gas-fired shaft kilns in Greece, and also some suitable iron ores, and the desirability of co-operation among manufacturers is suggested with a view to having trials made in Greece on good practical lines under experienced British management, assisted by a scientific expert who could accurately describe the course and result of each trial. In this way the possibility of obtaining from Greek magnesite a product with properties closely corresponding to those of the Austrian material could be definitely decided.

According to a German report, a pressure of 300 tons is applied in the moulding of Austrian magnesite bricks, which weigh 4¼ tons per thousand. With the pressure used here it is possible by adjustment of the milling and moulding plant to raise the weight from the standard 4 tons to 4¼ tons per thousand.

The main conclusions drawn by the author from microscopic examinations comprise the following: Crystal growth can take place with proper application of heat, and such crystal growth takes place more quickly and more regularly when the impurity is uniformly distributed through the whole of the magnesite. The impurity-magma should be able to inter-penetrate the finest interstices of the magnesite particles, rather than to simply coat the particles, or failing this the percentage of impurities should be correspondingly less. If these particles are unaltered from their crypto-crystalline state after calcination, and bricks made from such magnesite are built into furnaces working at a white heat, the particles are continually undergoing alteration from the small to the large crystal state with greater porosity between these crystals, until by continued spalling of the face of the brick next the furnace (where the greatest contraction has taken place) the new section of the brick with altering particles is exposed to the direct action of the slag, which can penetrate the pores and cause frothing with greatly increased porosity. As in certain specimens of Greek magnesite, which had been calcined at about 1,750 deg. C. in modern gas-fired shaft kilns, the conversion of crystalline particles has taken place almost throughout the specimens, but without perfect regularity of crystal growth, it is probable that if the attention of the works management were called to this fact, the conversion of the crystal growth from the crypto-crystalline state to the larger crystal formation would be attained more uniformly. When ferric oxide is present in these specimens the conversion from the crypto-crystalline to the massive crystalline is much more regularly attained, within a certain distance from the ferric oxide, and the structure is then closely comparable to that of the Austrian product. The British-made Greek magnesite bricks, whose micro-section corresponds most closely to the Austrian brick as regards both the regularity of growth and the microscopic appearance of the magma, are the ones which have given the best results in furnace linings.

It is gratifying to report that in the course of a brief discussion of the paper, the manager of an important steel works testified to the great improvement in British magnesite bricks during the past eight or nine months.

Personal.—Messrs. J. Lord, Limited, engineers and furnace constructors, Crown Works, Stockport, have now engaged Messrs. J. and S. Ogden, of Reddish, as furnace experts, in connection with the erection and repair of Siemens furnaces, also the crucible-type melting furnaces and carbonising furnaces.—The Langdon-Davies Electric Motor Company, of 110, Cannon-street, London, E.C. 4, will in future be known as "Brittain's Electric Motor Company."

The Mineral Resources of Great Britain.—A second edition of the third volume of the Special Reports on the Mineral Resources of Great Britain, prepared by the Director of the Geological Survey in response to numerous inquiries, has just been published. In the main it is a reprint of the first edition, wherein the properties, uses, treatment and modes of occurrence of gypsum, anhydrite, celestine and strontianite are dealt with. Details of the workings in all parts of Great Britain are given, with statistics as to output. In this edition some additional matter respecting deposits of gypsum in Nottinghamshire and Somerset, and estimates of the reserves of gypsum existing in the various districts described, have been added. Copies, price 2s., may be obtained through any bookseller from Messrs. T. Fisher Unwin, Limited, 1, Adelphi-terrace, London, W.C. 1.

1,000-TON FERRO-CONCRETE MOTOR VESSEL ON THE ALFSEN SYSTEM.

CONSTRUCTED AT THE PORSGRUND CEMENT WORKS, PORSGRUND, NORWAY.

Fig. 1.

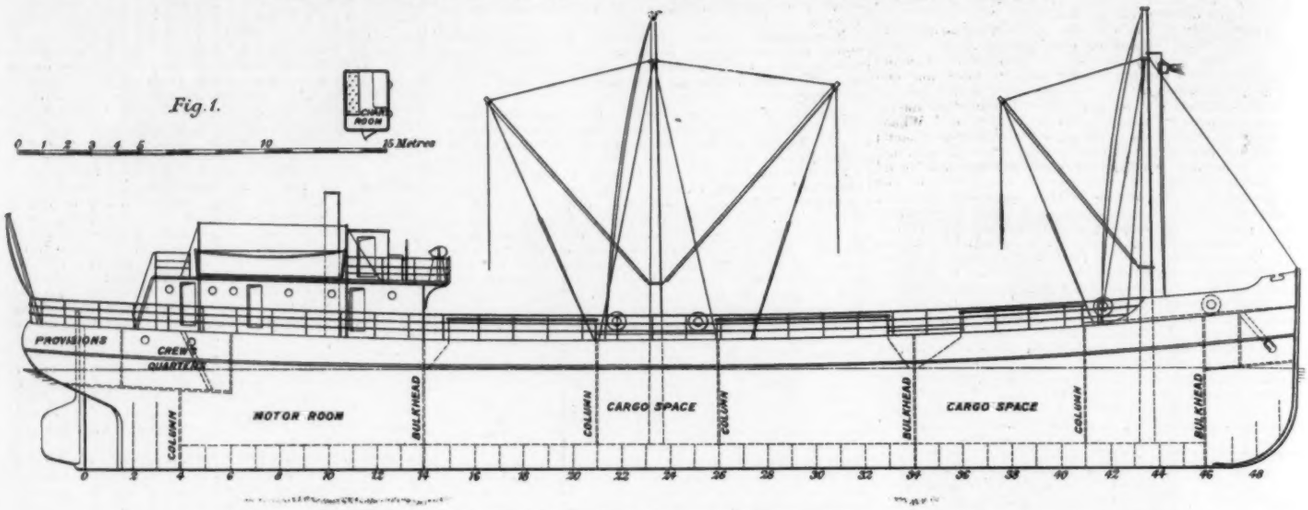
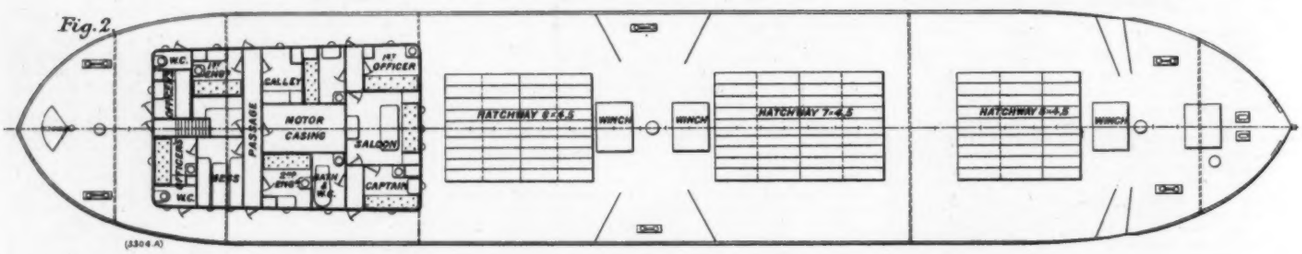


Fig. 2.



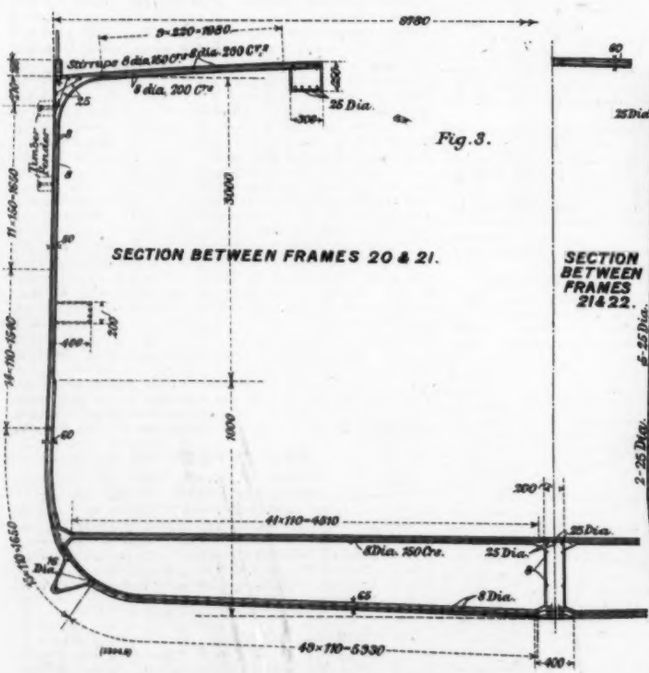


Fig. 3.

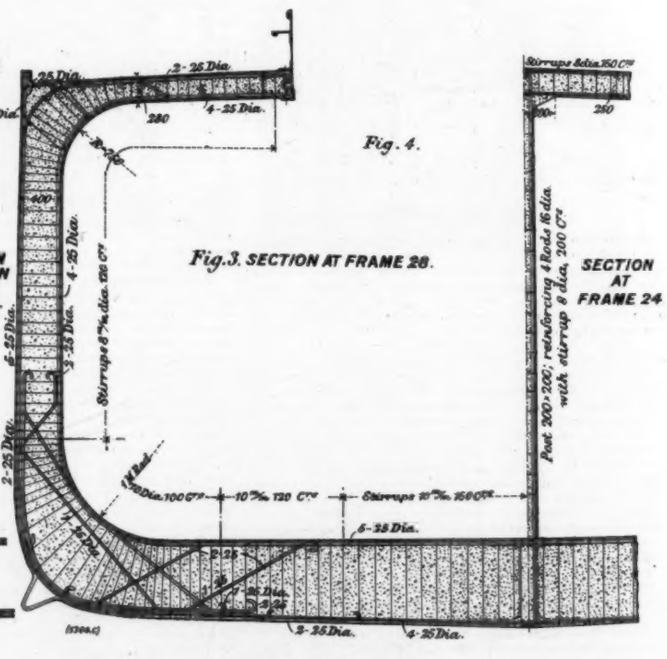


Fig. 3. SECTION AT FRAME 28.

Fig. 4.

FERRO-CONCRETE shipbuilding continues to extend and new concerns keep springing up for the exploitation of the different systems. In Budapest a company has been formed with a capital of 2,000,000 kr., and the vessels will be built according to the Rüdiger system, which is also being used in Hamburg. The Budapest yard will make a speciality of 700-ton lighters for the Danube traffic, for which the general shortage of tonnage also seems to prevail. In New York a company has been formed with a capital of $1,000,000, besides free shares, in addition to which the mother company, in this case the Norwegian Fougner Steel-Concrete Shipbuilding Company, also has secured some ordinary shares. The Fougner yard in Moss is fully employed, and some time ago as many as 22 boats had been launched. This number comprises a lightship for the Ildjernsflu; another vessel has been built as a tank boat and will be used for fresh water supply in the Christiania harbour. The company has orders for 15 boats and materials enough to build them. Also the Porsgrund yard, exploiting the Alfsen patents, is doing exceedingly well, and the method, of which full description has been given in these columns, has been adopted in a number of countries, where companies have been formed under favourable conditions.

We publish above and opposite drawings of a 1,000-ton vessel from the Porsgrund yard. Figs 1 and 2 show longitudinal section and plan of the vessel, Figs. 3 and 4 are cross-sections, and Figs. 5 and 6 vertical and horizontal sections. The total length is 172 ft. 3 in. and the depth 20 ft. 3 in. There are 49 frames in addition to the three in the overhanging stern. The motor is at the stern (Fig. 2) and the accommodat on for captain and

1,000-TON FERRO-CONCRETE MOTOR VESSEL ON THE ALFSEN SYSTEM.

CONSTRUCTED AT THE PORSGRUND CEMENT WORKS, PORSGRUND, NORWAY.

Fig. 5.

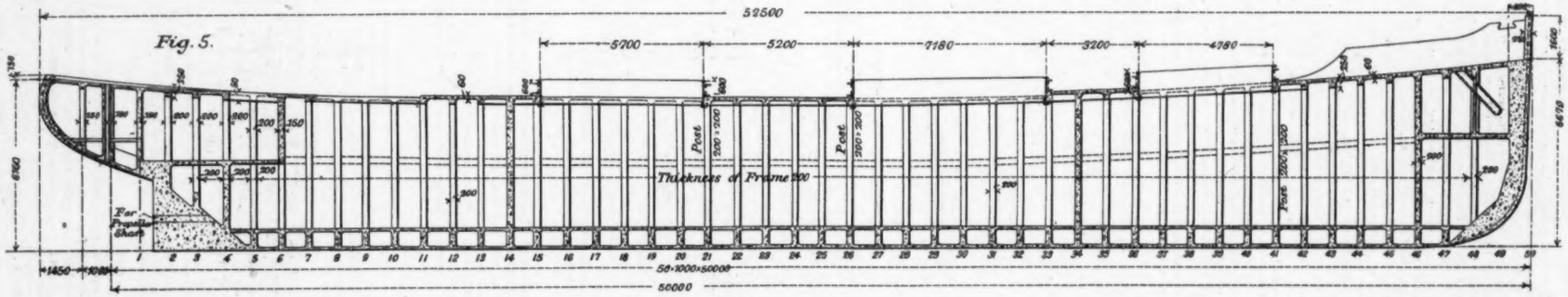
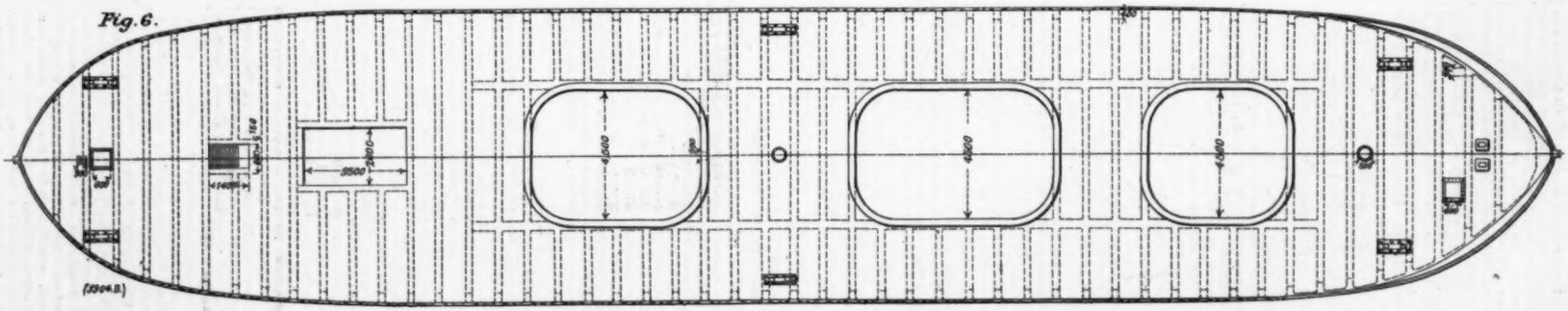


Fig. 6.



crew is above it. The motor room is separated from the cargo space by a bulkhead, and in addition to the collision bulkhead there is another dividing the cargo space into two unequal portions, to which access is obtained by three hatchways, of which the largest measures 29 ft. 6 in. by 14 ft. The frames (Fig. 4) are each 16 in. deep at the sides, and 34 in. deep at the bottom. The corners between the side frames and the deck beams and bottom beams are well rounded, and in the latter case diagonal ties are inserted. The reinforcing steel is an inch in diameter. There are five bars on the outside of each vertical frame, and two bars on the inside. In the bottom beams there are at the outside, four bars near the centre, and two near the ends, while in the upper flange there are five. The deck beams have two rods in the upper flange and four in the lower. The sides of the vessel, between the beams, are 2 in. thick in the upper part, and nearly 2¼ in. in the lower part. The reinforcement is 0·32 in. in diameter. Many more dimensions will be found on the drawings expressed in millimetres.

Several ferro-concrete vessels, which are completed, have experienced some difficulty in obtaining the necessary oil for their motors. Norwegian Veritas and the ferro-concrete vessel committee, however, applied for authorisation as regards the supply of oil, considering the importance of obtaining fresh experience with these new boats and their seaworthiness, before the comparatively large number of bigger ferro-concrete vessels, now in course of construction, were launched.

In Denmark, besides the Jutland company formed to build vessels according to the Alfsen method, a company has been started to take over and extend the Nästoed ferro-concrete shipyard. Last summer this yard built a 21-ton ferro-concrete lighter, which was passed by Lloyds, and a 125-ton sea-going lighter is now being built to Lloyd's class for coasting vessels. The slips will now be extended and hulls will be built, so that the building can proceed irrespective of the weather. The yard is experimenting with a considerably lighter cement which, if successful, will mean a material saving in weight. The company means to standardise its work so as to make it comprise, in the meantime, 200-ton to 300-ton deadweight motor schooners and motor vessels, 125-tons to 300-tons sea-going lighters and 20-ton lighters for towing. It is also under consideration to build ferro-concrete floating docks, tug and water tank boats, for which latter purpose ferro-concrete must be looked upon as an ideal material.

PROTECTOR FOR SMALL TWIST DRILLS.—We have received from the Central Drill Protector Company, of Halton House, 21–23, Holborn, London, E.C. 1, a sample of their protectors for small twist drills. This protector consists of a brass tube, slit for part of its length, so as to slide easily on the drill it protects. These protectors are made in sizes varying by 64ths of an inch, to suit drills of from $\frac{1}{16}$ in. to $\frac{7}{64}$ in. in diameter, and we think that users of such small twist drills will find that they will save many breakages. We understand that they have already been supplied to several aircraft factories.

ELECTRIC PREPARATION AND PRECIPITATION OF PHOSPHORIC ACID.—Last year we noticed (ENGINEERING March 23, 1917, page 276) experiments carried out by the United States Bureau of Agriculture on the preparation of phosphoric acid. A mixture of natural calcium phosphate, sand and coke was heated in an electric furnace, and the resulting fumes of phosphorous and phosphoric acid were, after cooling in a tower, sent up vertical tubes for the electric precipitation of the fumes on the Cottrell system. From *The Journal of Industrial and Engineering Chemistry*, January, 1918, pages 35 to 38, we see that the Bureau of Soils has resumed these experiments in co-operation with several firms. A 200-kw. plant was installed in the works of the R. B. Davis Company, of Hoboken, New Jersey. Conditions were imperfect, as generally in such runs, but favourable conclusions are drawn, and a cost estimate is offered. Runs lasting more than 10 days are mentioned. The average production of phosphoric acid, reckoned as H_3PO_4, was only 0.3 lb. per kilowatt-hour; 0.6 lb., it is said, might have been gained. The fumes were cooled to 250 deg. or 300 deg. C. in the tower and then entered the treater pipes from below. There were 20 treater pipes, in five rows of four each, all 12 in. diameter and 15 ft. high, made in sections and set in brick below and concrete above. In each tube a monel wire was axially suspended from a high-tension pipe above; the wires were weighted below, but there is no mention of their being shaken at intervals and interconnected below for this purpose, as was done in the previous experiments. The pipes are described as vitrified sewer pipes; the descriptive details are defective. With a high gas temperature (up to 300 deg. C.) an acid of 93 per cent., and even of 97 per cent. H_3PO_4 was obtained; with gases at 100 deg. C. the concentration hardly exceeded 50 per cent.; to go above 300 deg. C. is undesirable for several reasons. The precipitated acid runs down the pipes and is collected in a basin. The acid may contain fine dust from the coke and sand and also volatilised compounds of fluorine and arsenic from minerals frequently accompanying the phosphate in the natural rock. The slag from the furnace still contained 2 per cent. of phosphoric acid, which might have been reduced to 1.5 per cent., it is said. But the electric precipitation was satisfactory at a gas velocity of 3 ft. per second (which meant treating 2,000 cub. ft. of gas per second) by currents of 75,000 volts. It is to be hoped that these experiments will be continued. It might be mentioned on the other hand that "reverted superphosphate" has proved quite as good a fertiliser as normal superphosphate in Hawaii. Superphosphates are natural phosphates, the phosphoric acid of which is made soluble by their being treated with sulphuric acid. It is generally said that superphosphates must not be mixed with lime and not be used in ferruginous soil, lest the lime and the iron should combine with the phosphoric acid and make it "revert" into the insoluble state. If the experience made in Hawaii should be confirmed, one of the objections raised against superphosphates, and also against Thomas-slag and aluminium phosphates, would fall, and the phosphoric acid from the electric furnace would have to meet a strengthened competition.

SEA-GOING REINFORCED-CONCRETE BARGE.

MESSRS. J. AND W. STEWART, contractors, 42, Albemarle-street, W. 1, have built, in a dry dock at Brentford, a sea-going reinforced-concrete barge, the principal dimensions of which are the following: Length between perpendiculars, 150 ft.; breadth, 24 ft. 6 in.; depth, 13 ft. 6 in.; draught, 10 ft. 11½ in. The barge has a displacement of about 900 tons and a deadweight carrying capacity of about 400 tons on an 11 ft. draught. It is divided by four watertight reinforced concrete bulkheads into five compartments; the forward compartment is used for stores, holds and chain lockers, there are three central compartments for the stowage of goods, the aft compartment being set apart for the crew's quarters.

The barge is a towing barge for sea-going traffic, and is fitted with the necessary towing appliances; these include a length of 5-in. wire rope held in a nipper of the usual type and which runs at the bottom of a deep groove in a cast-iron block inserted in the bows. A hand windlass is provided forward, and a hand steering wheel and gear aft which operate a steel rudder.

About 260 cub. yards of concrete and 65 tons of steel bars have been used in the building of the craft. The sides and watertight bulkheads are 3·5 in. thick, and the bottom, which is flat, has a thickness of 4 in., the construction being strengthened at intervals by internal ribs of reinforced concrete. The flooring of the aft compartment and holds is made of wood planks. A reinforced concrete bulwark, capped with a wooden rail, extends over a length of about 25 ft., fore and aft; stanchions carrying a chain are provided along each side of the deck. Two wooden fenders surround the hull to prevent any chaffing of the concrete. All hawse holes and openings are surrounded by cast-iron linings for the same purpose. The deck, like the rest of the vessel, is of concrete. The three hatchway coamings are of reinforced concrete, covered with wood battens supported on built-up steel girders, and provision is made for battening them down in the usual way.

This being the first craft of its kind built in this country, it was thought advisable by the builders to make it of considerable strength, and both in the design and in carrying out the actual work, strength rather than lightness or economy has been the main consideration. Further, in order to establish a closer comparison between it and other craft, it has been constructed on the ordinary ship lines, which, of course, has added greatly to the labour and cost of manufacturing the wooden forms to the correct longitudinal and transversal curves. The result has been the production of a ship-shape craft having also, as far as can be estimated, a superior strength.

It has been built to Lloyd's regulations and under their inspection; it is classified A.1 with them.

LIGHT AND VISION—THE PHYSIOLOGY OF THE RETINA.—A paper on "Light and Vision," read before the Illuminating Engineering Society on April 16, by Professor W. M. Bayliss, F.R.S., of University College, London, dealt particularly with the "Physiology of the Retina." Three stages, he pointed out, may be distinguished in the phenomena which take place between the incidence of light on the cornea and the mental appreciation of it: (1) The formation of the image on the retina—a physical question, completely worked out, the only physiological component of the problem being the mechanism of accommodation; (2) light arriving at the rods and cones in the surface layer of the retina excites some photochemical change which, acting on the terminations of the optic nerve fibres spreading between these organs, sends a series of disturbances along these fibres to the (3) complex centres of nerve cells in the brain where the processes associated with the perception of light occur in some mysterious way. The nerve fibres themselves are not responsive to light energy; they only transmit the sensation, probably acting also as relays. The receptor organs seem to be the rods and cones. At the centre of distinct vision, in the *fovea* (yellow spot) there are only cones; near the periphery the rods predominate, and their functions seem to resemble those of the rods. According to Edridge-Green, however, it is the rods which secrete the visual purple, which is certainly the most important, if not the only, photochemical medium of the retina. Isolated with special precaution from the eyeball of a frog, this purple forms a fluid of beautiful red colour, which is bleached by daylight in half a minute, but resumes its colour in the dark. The purple is a colloidal liquid which stains the rods, at any rate after death; it is apparently decomposed by the light which it absorbs, but the components recombine when the excitation ceases; it is not actually produced in the fovea, but flows in from the surrounding parts of the retina. The time-lag in vision, after-effects, fatigue, &c., in the eye all seem to be connected with the purple; that the chemical change is primarily produced in the purple, and secondarily only in the rods and cones, is according to Edridge-Green supported by the fact that the situation and form of the after-image can slightly be altered by jerking the head and thus causing the purple fluid to be displaced.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Still the pressure for the delivery in ever-increasing quantities of steel of all grades goes on and the earnest desire of everyone engaged in the steel-making industry is to speed up production and add to the output. Meantime, of course, the entire plant in the West of Scotland is fully employed, as steel for shell bars and shipbuilding sections is in constant demand. Indeed, by far the larger portion of the steel at present being turned is requisitioned for the shipyards, where the activity is phenomenal. Billets, slabs and other semi-finished material are also greatly in demand, and constant inquiries are being made in respect of the chances of early delivery. Export trade sinks further and further into insignificance.

Malleable Iron Trade.—Malleable iron, like steel, is in such urgent demand that every mill is running to its utmost capacity, and makers have enormous outputs to their credit. Best iron is in great request for wagon builders, and in railway workshops where large quantities are dealt with.

Scotch Pig-Iron Trade.—With the home demand for pig-iron for work of national importance ever on the increase, and licences for export being granted only under very exceptional circumstances, overseas shipments have tapered off. Prices, too, remain strong. Home rates, of course, are unchanged.

Ironmoulders' Wages.—The Scottish ironmoulders will no doubt be much disappointed at the terms of the award which has just been issued by the Committee on Production in response to the recent demand made by the Central Ironmoulders' Association and the Associated Ironmoulders of Scotland for an advance of wages of 100 per cent. on pre-war rates, and for an increase of 30 per cent. on all pre-war piece prices jobs. The finding of the committee does not favour the men, as in their estimation present conditions do not warrant any such increase of wages as that advocated, although they have sanctioned an advance on piece-work prices, suggesting that the advance of 10 per cent given in March, 1915, be raised to 17½ per cent.

Scottish War Weapons' Week.—The returns in connection with the Scottish War Weapons' Week have now been completed, showing a most gratifying result. A sum of 10,000,000*l.* was aimed at—an average of 2*l.* 10*s.* per head of the population—but this has been considerably exceeded, the net result of upwards of 17,000,000*l.* coming out at rather over 4*l.* per head. Glasgow's contribution of 3,012,466*l.* tops the list, and is some 500,000*l.* odd over what the Second City expected to raise. The tombola organised by the Tramways Department raised 65,000*l.*, nearly 10,000*l.* of which will be expended upon local war charities and comforts funds, while on War Savings Certificates a sum of 50,375*l.* was expended.

GAS WORKS RETORT CARBON, &C., CONTROL ORDER.—An Order of the Minister of Munitions dated April 19 provides that until further notice no person may use, or trade in, gas works retort carbon, coke-oven carbon or pitch coke, without a permit. The order of January 10, 1917, relating thereto is cancelled, but the previous operation of that Order or the validity of any action taken thereunder or the liability to any penalty in respect of contravention prior to cancellation is not affected. Applications for permits should be addressed to the Controller, Non-Ferrous Materials Supply, M.S./R./C.L. Ministry of Munitions, 8, Northumberland-avenue, W.C. 2.

GERMAN WAR PROFITS AND WAGES.—The Consolidation Mining Company, Gelsenkirchen, last year earned 10,753,582 marks gross profit, against 10,558,288 marks the previous year. Of this sum, 7,500,000 marks were for coal and 1,500,000 marks for coke and auxiliary products. The average cost of labour in the coal-mining industry has risen from 5·68 marks per shift in July, 1914, to 9·92 marks in September, 1917, during which period the price for coal has risen 9 marks per ton. A reserve, principally for war tax, of 1,275,000 marks, was set aside. The net profits available amounted to 5,181,993 marks, against 4,950,925 marks for the previous year, and the shareholders again receive 22 per cent. The company's holdings of stocks has increased by 4,000,000 marks, war loan, &c., and the loan to the Fürst Leopold Gewerkschaft has risen to 16,700,000 marks.

RAILWAY BETWEEN BRITISH MALAYA AND SIAM.—Latest advices from the Far East are to the effect that the railway connecting British Malaya with Siam was nearing completion, and it was expected that through passenger traffic between Singapore, Kuala Lumpur, Penang and Bangkok would begin on April 1. As a matter of fact, trains conveying high officials in both countries have already been run over the line between Kuala Lumpur and Bangkok, and it is only the difficulty of obtaining certain ironwork that has prevented an earlier opening of the line to general traffic. One big iron bridge on the Siamese side had not been completed. The basal portion had been laid, however, and efforts are being made to get the ironwork fixed up as soon as possible. The completion of the through railway is expected to have an appreciable effect on the Federated Malay States food problem, as the Siamese authorities are anxious to send through as much rice and other foodstuffs as possible once the railway is open. Owing to the shortage of rolling-stock, due to the war, the through service will be a modified one at first, and it is not likely that there will be more than one passenger train daily each way till the war is over.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Taking a general survey of the trade position in Sheffield, one is confronted with a prospect of a somewhat unsettled character. Great activity prevails in departments concerned with the output of steel for shipbuilding, aircraft and tanks, and in other sections of the trade, while the operations are brisk, the orders are on the short side. At the heavy steel works the output chiefly consists of acid steel. Forges and mills are working unceasingly, and inquiries for heavy castings are numerous. In the crucible steel department conditions are not too satisfactory. It is this department to which greater freedom for exports would have come as a distinct advantage. The resolution of the Government not to relax the restrictions has occasioned disappointment in crucible-steel circles where makers are now able to produce more than they can sell. There is apprehension that trade connections may be affected, if not irretrievably lost. In the shell department a number of the sub-contractors have completed the orders entrusted to them, but as contracts have not been renewed they have turned their attention elsewhere for work to keep their plant in use. Less cupro-nickel is being asked for, and there is a certain quietness about the demands for some classes of tools. There has been a decline in the demand for railway springs, but that is more than made up for by the great quantities of spiral and laminated springs for automobiles and other vehicles which are being asked for.

South Yorkshire Coal Trade.—The effect of the Easter stoppage in the pits has not yet been thoroughly eliminated from the coal trade. All classes of coal for manufacturing purposes at home are in very great demand, and if supplies are forthcoming that demand will increase. Exports show little or no change. Gas fuels are being keenly sought. Business is confined to contracts. Considerable congestion has occurred at collieries where the order books both for contracts and for open market sales are pretty full. Quotations:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* to 14*s.* 6*d.*; seconds, 13*s.* to 13*s.* 6*d.*; smalls, 9*s.* to 10*s.*, per ton at the pit.

MUSICAL INSTRUMENTS SCIENTIFICALLY CONSIDERED.—In addition to the Royal Institution discourse on "Vibrations—Mechanical, Musical, Electrical," which we noticed on page 432 of last week's issue, Professor E. H. Barton, F.R.S., of Nottingham College, also gave, on the last two Saturdays, two very instructive lectures at the Royal Institution on "Musical Instruments Scientifically Considered." So far the subject does not concern the scientific instrument maker and the engineer. But it is certainly high time that science should more actively remember its indebtedness to the musical craftsman. How and to what extent the parts of a violin, a piano, a horn, &c., modify the tone the instrument is to give is very imperfectly understood, and men like Professor Barton fully recognise that they are confronted by problems that require a life study. In a measure that is perhaps as well. If musical instrument makers were to adopt hasty, pseudo-scientific advice, the harmony of our cherished old music might strangely be disturbed, and exaggerated modern musical eccentricities too powerful already, might predominate.

LOSSES OF MERCHANT TONNAGE.—The losses of British, allied and neutral merchant tonnage due to enemy action and marine risk are set out in the table below. The British tonnage lost in March was 216,003 tons, as against 254,303 tons in February, and 217,270 tons in January. It will be seen that the average losses per month this year are much lower than last year; in some cases less than half:—

Period.	Gross Tonnage.		
	British.	Allied and Neutral.	Total.
	Quarter.	Quarter.	Quarter.
1917			
January to March ..	911,840	707,533	1,619,373
April to June	1,361,870	875,064	2,236,934
July to September ..	952,938	541,535	1,494,473
October to December ..	782,889	489,954	1,272,843
1918			
January to March ..	687,576	435,934	1,123,510

The tonnage of steamships of 500 gross tons and over entering and clearing United Kingdom ports from and to ports overseas was as under:—

Period.	Gross Tons.
1917	
October	6,908,189
November	6,818,564
December	6,665,413
1918	
January	6,336,663
February	6,326,965
March	7,295,620

This statement embraces all United Kingdom seaborne traffic other than coastwise and cross-Channel.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is quiet. Buying, on home account, under the allocation system, has been practically completed for this month, and interest centres mostly in the question of distribution under existing contracts. With the improved truck supply, deliveries for April are fairly heavy, but even yet the wagon situation leaves much to be desired. A good inquiry for forge iron is reported, but as furnaces are working well, the quantity of this quality produced is not large. Export transactions are on only a very limited scale, and shipments are poor with the exception of those to France, which are well maintained through official channels. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge all stand at 95*s.*, and No. 1 is 99*s.*; whilst for shipment to France and Italy, No. 3 and the lower qualities are 114*s.* and No. 1 is 119*s.*

Hematite Iron.—In the East Coast hematite branch all home needs are adequately covered, and some surplus iron is available for export whenever cargo space can be arranged, foreign trade being entirely governed by the tonnage situation. The quantity of basic iron used for steel-making is now very large, and this has greatly relieved the stringency in hematite. Nos. 1, 2 and 3 hematite are 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for export to France and Italy.

Manufactured Iron and Steel.—In the finished iron and steel industries production is on an enormous scale, and is still growing, output of shipbuilding material being especially heavy. With manufacturers still fully employed on Government contracts and work for the shipyards, little opportunity is afforded for the transaction of ordinary commercial business. Prices, all round, are very strong. The following are among the principal market quotations:—Common iron bars, 13*l.* 17*s.* 6*d.*; best bars, 14*l.* 5*s.*; best best bars, 14*l.* 12*s.* 6*d*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.*; steel bars (no test), 15*l.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel hoops, 17*l.* 10*s.*; heavy steel rails, 10*l.* 17*s.* 6*d.*; packing iron and steel (parallel), 13*l.* 10*s.*; and packing iron and steel (tapered), 17*l.* There are no fixed prices for export, but approximately they may be given as 2*l.* to 3*l.* per ton above home quotations.

A Shipbuilding Deal.—As the outcome of a meeting this week of the directors of Messrs. W. Harkess and Co., Limited, the share capital of that firm has been transferred to two Cardiff gentlemen, and Mr. A. M. Ingledew and Mr. A. D. Greatrex become members of the board of directors in the place of Mr. Robert Mitchell and Mr. T. W. Ridley, who retire. Hitherto the share capital has been entirely held by the Harkess family and their friends, and it is understood that the transfer of shares will involve no change in the title of the firm or in the management of the establishment. Mr. N. Harkess will continue in his position as managing director, and Mr. Adam Weatherhead, who has for many years been associated with the concern, will retain his interest in the business. The shipyard, though small in extent—the building capacity being some 8,000 tons per annum—is one of the oldest on the Tees, having been established by the late Mr. W. Harkess in 1853.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Cardiff.—The demand for coal, especially the best qualities, continues undiminished, and practically all the Admiralty collieries are working to their fullest extent. Collieries producing the more bituminous coals are also well off, and the outlook on the whole is now no less promising than it was at the beginning of last week. In these circumstances it is feared that it will be difficult, if not impossible, for collieries to observe their obligations under the scheme recently brought into operation for the allocation of orders. The policy to which salesmen are as strongly committed as ever is that of taking the fullest possible advantage of the prevailing advantageous conditions. It may be possible for them later on to adjust production to the quantities allocated to them, but they decline to allow the outputs of their pits to be prejudiced by any domestic arrangement for the equalisation of orders, and will only agree to restrict outputs when there is no means available to lift their coal. The District Coal and Coke Supplies Committee further considered the problem of allocation at their meeting on Monday, but while it is the intention of the committee to adhere to the scheme, the members do not disguise the fact that the continuation of existing conditions may call for either the abandonment of the scheme or a drastic alteration in its conditions. Smalls are also relatively scarce, particularly those of the coking descriptions, while the supply of bunkers continues below requirements. There is a good supply of pitwood, both imported and home grown, deliveries being quite satisfactory, while reports from the iron works indicate a fair supply of iron ore.

Newport.—The demand of the authorities for Monmouthshire steam coals is fully maintained. It was reported yesterday that in one or two cases collieries were handicapped by a bad distribution of empties, but it is difficult to understand why any colliery should not now be regularly supplied with wagons when they are in such comparative abundance. The arrangements with regard to the transport of an increasing quantity of coal from Newport to Bridgwater by water are being made, but have not yet been completed. The main questions at issue are the adjustment of prices and the creation of factors' zone systems in the South-Western Counties, and these are now the subject of negotiation with the Controller of Coal Mines. The demand for the inland market is good, and at the moment there are no signs of a falling-off even in the inquiries for coal for house consumption.

The Supply of House Coal.—The question of the supply of house coal was considered by the South Wales Coal and Coke Supplies Committee at a meeting held on Monday. It was decided to make representations to the Coal Controller that South Wales be excluded, at least for a time, from any system adopted for the rationing of house coal, inasmuch as collieries in the South Wales coalfield, under the scheme for the allocation of orders, are only allowed to produce a permitted output. The committee, however, desired to urge upon all consumers the importance of stocking coal during the summer months as far as possible, in view of anticipated transport difficulties and shortage of labour in the winter months. It was further intimated by the secretary, on behalf of the committee, that consumers should distinctly understand that the quantities of first-grade house coal are very much reduced owing to the number of men now being taken from the mines, and that they will be still further reduced when the additional number of men are called up. Householders, therefore, must be willing to accept second grade, and even third-grade house coal and anthracite coal. The committee also desire to emphasise the importance and absolute necessity of consumers agreeing to take such coal.

Transport by Rail of Coal for Shipment.—There were issued to-day by the South Wales Coal and Coke Supplies Committee the Directions of the Controller of Coal mines as to the transport by rail of coal for shipment from collieries in South Wales and Monmouthshire. It is laid down in the directions that (1) except with the consent of the Controller of Coal Mines no person shall supply coal from any of the collieries specified in an appended schedule to be forwarded by rail for shipment, whether as cargo or bunkers, at any port between Newport and Burry Port inclusive, except in accordance with these Directions. (2) Coal shall not be supplied from any of the collieries specified in the schedule to be forwarded by rail for shipment, whether as cargo or bunkers, at any port between Newport and Burry Port inclusive, other than the port or ports specified in the schedule from the colliery in question. (3) Where coals are mixed they are to be shipped at the port or ports specified in the schedule for the colliery supplying the largest portion of the cargo; provided that mixed cargoes of small coal may, when necessary, be shipped at the port most convenient in the circumstances. (4) Monmouthshire coal for bunkers may be shipped at either Cardiff, Penarth or Barry when the cargo of the steamer taking the bunkers is ordered to be shipped at these ports. (5) These Directions shall not apply to coal forwarded for shipment in accordance with instructions given by the Admiralty. It may be added that the guiding principle underlying the whole scheme is that coals must be taken to the ports which are most easily accessible to the producing collieries. For example, collieries in the Western part of the coalfield are directed to forward their coals to Swansea, Port Talbot, Neath, Briton Ferry, Llanelly or Burry Port. Those collieries which are situated in a line east of Bridgend, such as the Rhondda Valley, are directed to send the coal to Cardiff, Penarth or Barry, and Monmouthshire collieries to Newport. It will thus be seen that the object aimed at is to economise transport, and particularly to relieve the congestion on the Great Western Railway.

SINGLE-PHASE 1,200-H.P. GOODS LOCOMOTIVES.—On the Magdeburg–Halle–Leipzig railway, one of the busiest lines of Central Germany, three 1,200-h.p. locomotives were recently introduced for dealing with the goods traffic. Since then 27 new locomotives have been ordered. The engines are built by the Allgemeine Elektrizitäts-Gesellschaft and are worked by single-phase currents of 13,500 volts and 16⅔ periods per second. Each engine carries two motors; the speed is 50 km., about 30 miles, per hour.

WOLFRAM, MOLYBDENITE AND BISMUTH IN QUEENSLAND.—The chief centre of the production of the three minerals, wolfram, molybdenite and bismuth, in Queensland is the Cairns hinterland, which includes the Herberton and Chillagoe mineral fields; and an important factor in the recent history of this part of Queensland has been the erection at Bamford of a State reduction and concentrating plant for the treatment of ores containing wolfram, wolfram-bismuth, molybdenite and all three minerals combined. The chief producers of pure wolfram in the Herberton district—and indeed within the Commonwealth—are the Mount Carbine Mines, where the increased output has not detracted from their future stability. The magnitude and quality of the Mount Carbine wolfram deposits are worthy of more serious consideration than they have yet received as regards cheaper power for mining and milling purposes. The centre now ranking second among the greater producers of wolfram is Wolfram Camp, or Wolfram, but there it is always in association with bismuth and molybdenite, the product generally being a mixture of bismuth and wolfram. While special prominence cannot this year be claimed for any individual mine, amongst the foremost producers may be ranked the Murphy and Geaney, Larkin and Wade, Hughes, and Tully Tribute, while good and consistent patches have been worked in the Enterprise, Mount Maguire, Leisner's Wolfram Block and several others.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, April 26, at 8 p.m., at 39, Victoria-street, Westminster. Lecturette, "Refrigerating Chambers and Heat Insulations," by Mr. E. C. West.

THE PHYSICAL SOCIETY OF LONDON.—Friday, April 26, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, S.W. Agenda: 1. "Notes on the Pulfrich Refractometer," by Mr. J. Guild, A.R.C.S., D.I.C. (of the National Physical Laboratory). 2. "On the Accuracy Attainable with Critical Angle Refractometers," by Mr. F. Simeon, B.Sc. (of Adam Hilger, Limited). 3. "Cohesion" (fourth paper), by Professor Herbert Chately.

THE JUNIOR INSTITUTION OF ENGINEERS; NORTH-EASTERN SECTION.—Tuesday, April 30, at 7.15 p.m., at the Miner's Institute, Newcastle-on-Tyne, papers will be read on "Synchronous Clocks" and "The Soldering of Aluminium."

THE ROYAL SOCIETY OF ARTS.—Tuesday, April 30, at 4.30 p.m.: Colonial Section: "British Guiana," by Sir Walter Egerton, K.C.M.G., LL.D., Governor of British Guiana, 1912–17. Sir Everard im Thurn, K.C.M.G., C.B., will preside. Wednesday, May 1, at 4.30 p.m.: Ordinary meeting: "Sugar from Several Points of View," By Mr. George Martineau, C.B. The paper will be read by Mr. Edward R. Davson, President of the Associated West Indian Chambers of Commerce. Thursday, May 2, at 4.30 p.m.: Special Lecture: "The Freedom of the Seas," by Mr. Gerard Fiennes. Mr. J. L. Garvin will preside. Lecture I—Freedom Without Law; Law Without Freedom; Law and Freedom.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Tuesday, April 30, at 7.0 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Newcastle-on-Tyne. "High-Speed Internal-Combustion Engines," by Mr. Harry R. Ricardo.

THE INSTITUTE OF METALS.—Thursday, May 2, at 5.30 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. 1, the Eighth Annual May Lecture will be delivered by the Hon. Sir Charles A. Parsons, K.C.B., F.R.S., on "The Formation of Diamond."

THE IRON AND STEEL INSTITUTE.—Annual meeting in the House of the Institution of Civil Engineers, on Thursday and Friday, May 2 and 3. Thursday, May 2, at 10.30 a.m., general meeting of Members. The Council will present their Report for the year 1917, and the Hon. Treasurer will present the statement of accounts for 1917. The retiring President (Sir William Beardmore, Bart.) will induct into the chair the President-elect (Mr. Eugene Schneider). Mr. Schneider will present the Bessemer Gold Medal to Sir William Beardmore. The President will deliver his Presidential Address. Papers Nos. 2 and 4 will then be discussed. Adjournment of meeting. 2.45 p.m.: Papers Nos 5, 3, 6 and 7 will be discussed. Adjournment of meeting Friday, May 3, 10.0 a.m.: Papers Nos. 10, 13, 12, 11 and 18 will be discussed. Adjournment of meeting. 2.45 p.m.: Papers Nos. 14, 15, 17 and 16 will be discussed.—1. Presidential Address by Mr. C. Eugene Schneider. 2. Report of the Blast-Furnace Committee, "Practical Points affecting Yield and Efficiency of Blast furnaces." 3. "Importance of Coke Hardness," by Mr. G. D. Cochrane. 4. "Economic Value of the Jurassic Iron Ores of Great Britain," by Dr. F. H. Hatch. 5. "Fuel Economy in Blast Furnaces," by Mr. T. C. Hutchinson. 6. "Note on Use of Copper Tuyeres," by Mr. A. K. Reese. 7. "Potash Recovery from Blast Furnaces," by Mr. Kenneth Chance. 8. "Blast-Furnace Bears," by Dr. J. E. Stead. 9. "Technical Aspects of the Establishment of the Heavy Steel Industry in India, with Results of some Researches connected therewith," by Dr. A. Macwilliam. 10. "Production of Sound Steel by Lateral Compression of the Top Portion of the Ingot," by Mr. B. Talbot (not available for distribution). 11. "Steel Ingot Defects," by Mr. J. N. Kilby. 12. "Notes on Inclusions in Steel and Ferrite Lines," by Dr. J. E. Stead. 13. "Non-metallic Inclusions in Steel," by Mr. A. McCance. 14. "A Cause of Brittleness in Mild Steel Boiler Plates," by Dr. W. Rosenhain and Mr. D. Hanson. 15. "Effect of Mass on Heat Treatment," by Mr. E. F. Law. 16. "Effect of Cold Work on the Divorce of Pearlite," by Mr. J. H. Whiteley. 17. "Effect of Cold Working on the Elastic Properties of Steel," by Mr. J. A. Van den Broek. 18. "Iron, Carbon and Phosphorus," by Dr. J. E. Stead. 19. "Damascene Steel," by Colonel N. Belaiew. 20. "Protection of Iron with Paint against Atmospheric Corrosion," by Dr. J. N. Friend. 21. "Determination of Cobalt and Nickel in Cobalt Steel," by Mr. W. R. Schoeller and Mr. A. R. Powell.

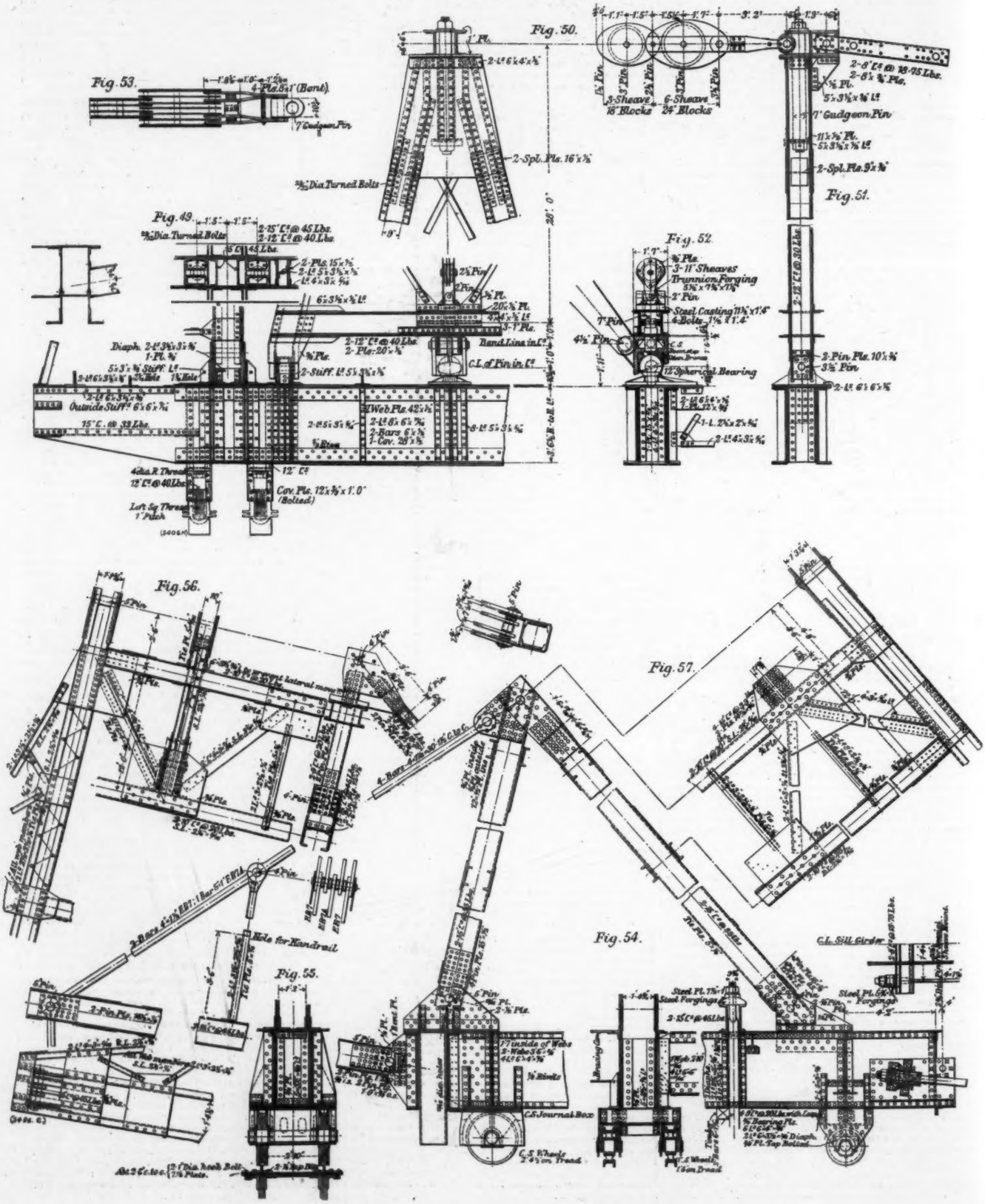
THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, May 3, at 6 p.m., at the Institution of Civil Engineers, Great George-street, S.W. The paper on "War Work of Women on Munitions Production in Engineering Shops," by Mr. Ben. H. Morgan, announced for the last meeting will be read and discussed, and the discussion on Miss Monkhouse's paper on "The Employment of Women in Munition Factories" will be concluded.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Wednesday, May 1, at 5 p.m., annual meeting. Friday, May 3, at 5.30 p.m., a discourse will be delivered by Sir George Greenhill; the subject will be "The Spinning Top in Harness." Afternoon Lectures at 3 p.m.:—Tuesday, April 30: Professor Arthur Keith, M.D., F.R.S., Fullerian Professor of Physiology at the Royal Institution, on "Cave-Hunters" (Lecture II). Thursday, May 2: Sir Isambard Owen, M.D., LL.D., on "Rheims Cathedral" (Lecture II). Saturday, May 4: Professor H. F. Newall, D.Sc., F.R.S., on "Modern Investigation of the Sun's Surface" (Lecture II).

THE SCIOTOVILLE BRIDGE OVER THE OHIO RIVER.

MR. GUSTAV LINDENTHAL, NEW YORK, ENGINEER.

(*For Description, see Page* 451.)



FIGS. 49 TO 57. DETAILS OF THE CREEPER TRAVELLER.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 459.

ENGINEERING.

FRIDAY, APRIL 26, 1918.

MAN-POWER AND PROTECTED OCCUPATIONS.

THE passage of the Military Service Bill and the issue of the first Proclamation under the Act define a new stage in men's liability to military service. To engineers it will be remarkable chiefly for the fact that, except for a qualified assertion of the clean cut up to 23, protection within their trades remains as it was. A man logged as belonging to a protected calling and engaged on it for war purposes continues to be exempt from military service.

Whether this provision is consistent with using man-power to the utmost extent depends obviously on whether men of military fitness are allowed to be engaged on war work in protected occupations when it could be done by others. Manufacturers know in the way of business that the country needs a maintained or increased output of war supplies; but as citizens they know also that it needs men for the service of its armies. The recent course of the war seems to show plainly that if these men had been recruited a year ago, the army might have held a better line in France than it holds to-day, and have paid a less toll. The warning that more men would be needed came long ago. At the end of 1916 the Commission on Man-power advised the Government of the need for large increases; and in the course of last year attention was repeatedly drawn in these columns and elsewhere to the fact that a large number of men of military age appeared to be retained in protected occupations when they could be replaced by women without injury to output.

Some improvement has presumably taken place in this respect; but information from all parts of the country, confirming what we have seen recently with our own eyes in the Birmingham district, leaves no doubt that far more men are still retained in munition trades when they could be replaced without loss of output than should be tolerated in any circumstances of general conscription. Administrative authorities nowadays have constantly to deal with problems that in kind or in scale are beyond all precedent. The situation is unavoidable. It gives no ground for cavilling at what events may show to have been errors of administration, or even for trying to avoid incidental mistakes by seeking the worse evil of a divided control. But it does impose on those who know the facts the duty of expressing them plainly for the information, not alone of the public, but of authorities to whom they may at best be accessible only at second-hand.

It is not too much to say that in some branches of the engineering trades no adequate attempt seems to have been made to apply the labour of women to the purposes for which it could be used. This default is apparent notably in shipbuilding and marine engineering. Competent observers have remarked that British industry would have a better chance of doing itself justice if it could apply to the purpose of getting things done a fraction of the ability, resource and determination with which it sometimes sets itself to prevent them from being done. The position of shipbuilding and marine engineering to-day in respect of the employment of women is indeed a case in point. The application of this measure in these trades has been sturdily and successfully opposed; and whether the credit is due to the leaders of the industry or the workmen or the Government Departments concerned, the result is that shipyards and marine shops have gone on without as large population of willing women workers as might have been added to its staffs. The country's shipping is notably below what it might have been if its resources in man-power and woman-power had been used fully.

The default is seen eminently in these industries because of their size, their importance, and the powerful Government backing which has enabled them to maintain their conservative attitude; but it penetrates a large number of other branches of trade. In these branches women are not excluded so consistently from the shops, but the extent of default that is avoided by their partial or occasional admission is more than offset by the width and variety of the industries infected. Evidence enough was to be seen even in the Birmingham district, where in many shops advantage has been taken of women's work, both before and during the war. It has long been clear, for instance, that women can be trained in a relatively short time to do machine work of the closest accuracy. The impression that their powers are limited to automatic-machine minding or even to strictly repetition work, natural though it may have been at the outset, has long been known to be unfounded. In some shops accordingly they are making small tools to exact sizes. In others they are acting as tool-setters. Yet in the tool-rooms and among the toolsetters in works upon works of the Birmingham district not a woman is to be found; and what is true in this respect of Birmingham is paralleled by instances from most other parts of the country. Here and there, again, a foundry is seen to be employing women with success on moulding by hand and by machine; yet in spite of the unprecedented volume of long runs, undoubtedly favouring the employment of newly-trained labour and the provision of lifting appliances to help out inferior muscle, few foundries seem to be making much appreciable use of women. Men, again, are found in great numbers, clinging to trumpery operations of sheet-metal working which in their very nature seem more fitted to women than to the hefty fellows who are engaged on them. Shopfuls of men may even be found filling cartridges, while in other shops women are doing the same work as well or better. We can only quote a few examples where the Government should know quantities; but the examples that have come under our notice are such and so numerous, and from shipbuilding to the manufacture of aero engines and aircraft cover so large a number of trades, as to leave no doubt that they represent a vast enclave of man-power, detained needlessly in industries where it could be replaced by women.

The primary reason alleged in extenuation of this state of things is that all the output of the trades in which the men are engaged is wanted for urgent war needs. The statement is not to be doubted; but it begs the question, which is whether some—apparently in the aggregate a large number—of these men are not doing work that could be done by women. No one proposes to reduce output; but if women can produce it, as now is beyond question, they can replace men, and the men so replaced can go either to work that women cannot do, or, like their comrades in other occupations, to military occupations.

"WAR USURY" IN GERMAN INDUSTRIES.

To those who have watched recent industrial developments in Germany, it has often been a matter of wonderment, that undertakings engaged in war contracts should have been allowed to earn

such extravagant profits. The explanation is probably to be looked for in the privileged position enjoyed in Germany by the "heavy" industries, and by the exceptional and powerful influence which half a dozen of the leading men within the iron, coal and steel trades, and one or two other branches are allowed to exercise. The matter has not been allowed to pass unnoticed by the more liberal portion of the press, but this criticism has so far been unavailing. Until the subject was brought before the chief committee of the Reichstag no attempts were made to put a stop to such abuse. The immediate occasion was a report presented by the second sub-committee on the prices charged and profits earned by concerns supplying the weapon and munition department; more especially as regards motor cars.

It was pointed out that manufacturers of cars made excessive profits, expecially those engaged on standard types. In this connection special reference was made to the Daimler works. A former employee of this firm had stated, that the Daimler works had purposely mystified their accounts. This caused a commission to be sent to Stuttgart in order to look into the matter. Several of the works favoured with army contracts declined to furnish sufficient material for a subsequent investigation of the prices charged. The Daimler undertaking was found to have earned 4,000,000 marks per month above their normal profits and yet demanded higher prices for their motors. It was stated, that the military authorities had the right to have the business books placed at their disposal. But it will be for the courts of law to decide, whether this demand can be enforced.

The director of the "Wumba," the department which watches over the fixing of prices for military contracts, stated that prices were fixed on the basis of the conditions existing during peace, with due considerations of war conditions. Thus the different branches were allowed additional costs of production and also additional profits. The savings resulting from the subsequent investigation of the prices demanded by the army contractors amounted, broadly speaking, to 50,000,000 marks per month. Generally there was no occasion to complain of any lack of courtesy on the part of the works, in spite of some opposition to begin with and many reasonable misgivings. A number of firms, however, still refused to place their books before the department. The demands made upon industry under the Hindenburg programme were immense. The original arrangements had to be revised, and the changes had brought about markedly unfavourable results for the State. The utmost efforts were made to overcome the difficulties, but the work entailed was exceedingly comprehensive and expert assistance very limited.

A socialist member pointed out, that the present question only represented a small section of the whole. Prices were raised to begin with without any careful calculation, and the opportunity for excessive profit-making remained. The "Wumba" did useful work, but it was mostly theoretical. The State ought to have secured a joint right of possession in connection with the new undertakings after the war. The English system of taking everything over would hardly do, but profit-earning ought to have been curtailed long ago. The Daimler works had at last declared they were willing to submit their estimates, but these had for years been systematically inflated. By another member it was maintained, that it was not only large, but also medium-sized and small concerns which had refused to show their books. There were arrangements which ensured for the State a share in the new undertakings after the war, and also a voice in the adjustment of subsidies. With regard to the Daimler episode the system of control hitherto followed was inadequate. It was strange that the dividends declared and the exchange of the shares did not arouse suspicion. The company had nominally increased their capital from 8,000,000 marks to 38,000,000 marks during the war in order to keep down the dividends. The old shares were quoted at 1,350 marks, and each old shareholder obtained a new share at par, 100 marks for each old share he held. Other speakers said that the war department's way of dealing with things was incomprehensible. If private concerns based their estimates on calculated costs from the Spandau State works as a basis in their army contracts, they were bound to make large profits, for the Spandau works by no means were cheap producers. The Oberndorf rifle company could, for instance, manufacture a rifle at 40 marks less than the Spandau works.

It will be interesting to see what will be the further outcome of this first serious attempt to stop "war usury in Germany."

THE PLACE OF SCIENCE IN EDUCATION.

THE defects of our system of selecting the class of officials from which our departmental heads are appointed have been made very evident by the events of the past four years. In normal times the convention by which the temporary political chief of a department and not the permanent official is assumed to be responsible for the efficiency of the service, was of inestimable value to both the politicians and the higher ranks of the official hierarchy. The two formed in this way a highly effective defensive alliance. If, for example, it were found that the official specifications for certain munitions of war were seriously defective, then by convention the blame did not attach to the technical advisers of the authorities but to the Secretary of State for War. As no reasonable man, convention or no convention, could hold the latter really responsible the effect has been that gross errors made by departmental officials have seldom been visited by any adequate penalty. In such cases the convention has served to protect the officials. On the other hand, the political head of a department may have acted against the expert opinion of the departmental chiefs; the convention then served to protect the Minister, since the officials had no right to insist on the public being informed of their real views. On occasion this convention has broken down, as when Sir William Harcourt's misrepresentation of the views of the Admiralty had to be withdrawn under the threat of a general resignation. Such instances, however, have been extremely rare; the compact has on the whole been faithfully observed, to the mutual convenience of both sides, whilst the consequent loss to the public was of little concern to either.

Such a state of affairs would naturally tend to the higher departmental posts being filled with men skilled in the art of discovering not what ought to be thought as to a proposed policy, but of contriving what could be said in its favour, and these qualifications were probably as well met by the ordinary Oxford "Greats" man as by any other. The existing crisis soon showed, however, the need for men of a wider culture, and these have had to be sought in fields where knowledge, insight and initiative were the price of success, rather than the mere ability to write a readable report, valuable as this accomplishment undoubtedly is.

It is not, however, only in our Government departments that administrative positions have been filled by men educated on the narrowly specialised lines of our public schools. In the past great manufacturing works were built up in this country and profitably operated by men who were themselves capable chemists. Their successors were too often typical products of our classical schools, with possibly a somewhat minute knowledge of the intricacies of the Greek and Latin grammars, but wholly unversed in, and often contemptuous of, any scientific or technical knowledge. The result has been admittedly disastrous, and the public has been gradually brought to recognise that the future prosperity of the country will depend largely on radical changes in our system of secondary education. What these changes should be is discussed in a report* published last week by a committee, with Sir J. J. Thomson as chairman, appointed to report on the position of natural science in the educational system of Great Britain. The report is a very exhaustive document, covering the whole course of education from the primary schools to the university. It brings out very clearly the privileged position hitherto held by classics. The vast majority of the entrance scholarships to our public schools are awarded on the results of competitive examinations in Latin and Greek. The bias thus given is commonly maintained throughout the whole of the rest of the school career, so that some 70 per cent. of public school candidates who gain classical exhibitions or scholarships at the universities have previously obtained classical scholarships when they entered their school. Of course there are some clever boys who may do well in classics and yet fail at mathematics or science, whilst some others, good at mathematics, may have little taste or relish for linguistics; but most clever boys will do well at either. Certainly any boy with a good head for mathematics will make his mark in classics if he is also the fortunate possessor of a good verbal memory. In the present condition of affairs, however, the dice are loaded, and an undue proportion of our abler lads specialise in classics.

At one time the defenders of the existing system maintained that any reform meant the abolition of all culture studies. The assumption that a knowledge of the Latin and Greek grammars is essential to culture appears now, however, to be abandoned, and in his defence last June, in *The Nineteenth Century*, of the vested interests threatened, Mr. C. E. Robinson has taken a much more modest line. He maintains, and with much reason that translation from one language to another affords easily graduated exercises of a boy's capacity for thought. He asserts —but, of course, does not attempt to prove—that translations from Latin are better adapted to this end than from modern languages; but his main contention in favour of the *status quo* appears to be that teachers know how to teach Latin and Greek, but not other subjects. Of course, there is the usual declamation against estimating the value of a study by its immediate practical utility; a point on which the advocates of reform are, however, in full agreement with himself. Nevertheless if, as in linguistics, the prime necessity of mental training can be combined with some utilitarian value, this latter should surely be reckoned to the credit rather than to the debit of the subject of study.

The report is, as already stated, of a very exhaustive character, and we are gratified to note that the recommendations made are, in repeated instances, in exact accord with what has been advocated in our columns. Thus the committee consider that the heuristic system of teaching science should be strictly limited in its applications. The student, they say, "cannot expect to rediscover in his school hours all that he may fairly be expected to know; to insist that he should try to do this is to waste his time and his opportunities." Again, it is observed that too much time is commonly spent in laboratory work, and that demonstration experiments by the lecturer are in many cases to be preferred. Further, the committee object to the practice for long in vogue in which the student was discouraged from using text books and impelled to rely solely on his lecture notes. It is, moreover, urged that much more attention should be paid than hitherto to the history of the growth of scientific ideas and principles. One other important recommendation is that elementary courses in science and mathematics should be arranged to aim at breadth rather than depth. The main difficulties in the way are the examinations for scholarships at the schools and the universities. These are of a highly specialised character, requiring a relatively advanced knowledge of some one particular subject, and even so, the type of question most in favour has been that which is easy to mark, rather than of a character to fairly test the intelligence of the candidate. One result is that the scholarships awarded at the entrance examinations to our public schools are to a very large degree beyond the reach of any lad whose parents are not in a position to pay highly for special preparation.

On the general question of scholarships and exhibitions the committee recommend a very large increase in their numbers, coupled with the restriction that the value of the scholarship shall be regulated by the needs of the successful candidate. It is proposed, in short, that the scholarships shall have primarily a nominal value; but that where the candidate really requires aid, the amount shall

* The Position of Natural Science in the Educational System of Great Britain. [Cd. 9011.] Price 9d.

be increased so as to secure to him throughout his university career a pecuniary position comparable to that of the average undergraduate. Finally, a large number of post-graduate scholarships should be provided. This reform has long been urged in ENGINEERING and would be of undoubted benefit to the nation.

Much stress is laid on the importance of research work, but we could wish that some criticism had been made of much indifferent work now classed under this title. There is a distinct tendency towards the assumption that research work must be laboratory work, and the claim to the title of original research is admitted even for experiments which are a mere record of measurements made without definite aim, and yielding no definite result but a useless compilation of figures unco-ordinated by any real addition to our knowledge. Many most valuable researches, however, have been made by men who seldom conducted an experiment. The establishment by James Thomson from thermodynamic principles of the fact that the melting-point of ice was lowered by pressure was a piece of research work of far higher order than were the experiments of his brother, which confirmed the conclusion. James Thomson again, when, in 1848, he demonstrated without the aid of a laboratory the importance of the elastic range of a material, accomplished a far finer piece of research than Bauschinger did in confirming these conclusions some thirty to forty years subsequently.

Laboratory experience and training are undoubtedly of very high value, but mere manipulative skill and accuracy in observation will in themselves serve for the equipment of a mere hodman of science. and we could have wished that the committee had definitely pointed this out. There are, at least, one hundred men who can conduct an average laboratory research for one who can make a real and assured step in advance. They do note that the provision of ample funds and facilities, even when these are intelligently administered, cannot ensure scientific work of the first class. The great discoveries are essentially individualistic in character, the man counting for far more than the equipment.

The committee strongly recommend that teachers of technology should be encouraged to take private professional practice. We believe this will be strongly resented by the committees of many municipal technical schools, but we are convinced that the plan will benefit both teacher and pupil. It may be noted in this connection that the usual insistence that candidates for professional chairs of engineering must have had prolonged teaching experience has had many bad results in widening the breach between the science of the class room and the practice of the shops.

The committee are, of course, very urgent on the importance of increasing the amount of time at present devoted in schools to culture studies. The humanities must not be neglected, although the Latin grammar may well be discarded for all but a few who desire to specialise in classics. The importance of English is insisted on, and it is noteworthy that Mr. Robinson, in the article already referred to, also admits the case for this study. He objects, however, that competent teachers are not to be had, and is averse, possibly from a vested interest in other subjects of education, to obtaining a supply by creating the demand.

One point is clearly apparent from the report, and that is that the class of man required for teaching either English or science will not be forthcoming unless the prospects of the teacher are very materially improved, as compared with existing conditions. Apart from any other consideration, moreover, it is hardly socially advantageous that men above the average in intelligence and entrusted with the training of our youth, should feel underrated and neglected.

With respect to our various national services, the committee note that no knowledge of science is necessary for admission to Sandhurst, and no knowledge of classics for admission to the Navy. As the Americans say: "It is up to" to the advocates of the *status quo* in educational matters to show that the average army officer is a better man than our naval officers. As to the manning of other Government Departments, the committee make the excellent suggestion that it should be the practice to fill some of the higher administrative posts not by promotion from within the ranks of the department, but by the selection of outsiders of proved ability. The department will, of course, bitterly resent such an innovation, and in normal times may rely in any particular instance on the support of whatever party happens to be in opposition. This difficulty might perhaps be surmounted by laying down definite rules, by which certain posts were filled in rotation by promotion and selection respectively.

RADIATION FROM SYSTEM OF ELECTRONS.

IN concluding the spring term of the Royal Institution on Friday, March 22, by a discourse on "Radiation from System of Electrons," Sir J. J. Thomson, P.R.S., O.M., dwelt on features to which he had not made any particular reference in the course of his lectures on "Problems in Atomic Structures," which he completed on the following day. In a certain way this discourse hence supplements the lectures, and the introduction to our brief notice of the discourse will perhaps best be understood

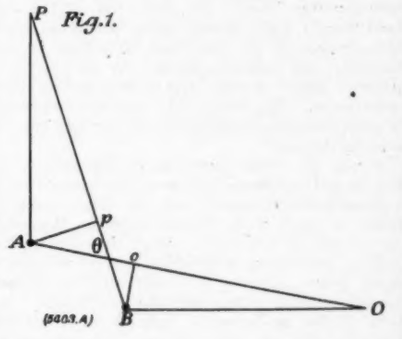


Fig. 1.

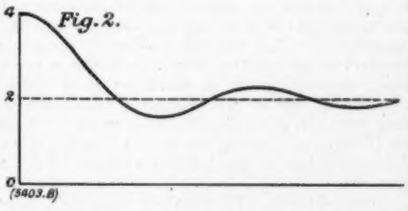


Fig. 2.

if we refer our readers to our more detailed account of the lectures on page 234 of our issue of March 1. We also for convenience of reference reproduce here the Figs. 1 and 2 published with our article just referred to. If light coming from O struck two electrons, A and B (Fig. 1), Sir Joseph said, it would be scattered in various directions, and the energy received at some point P would depend upon the relative lengths of the two paths, O A P and O B P. To demonstrate the scattering Sir Joseph let the beams of the lantern fall on two knitting needles, whose lengths corresponded to A B, held obliquely in the beam; on the screen two intersecting luminous arcs of the two needles were produced. With perfect coincidence of wave-length and phase the radiations from A and B would reinforce one another. The curve indicating the intensity of the scattering in various directions was a damped curve showing maxima and minima (as in Fig. 2); the maxima and minima would lie on cones and the apex angles, and thus the diameters of the rings which they produced on a screen, depended upon both A B and the wave-length λ, or rather upon the ratio d/λ (if A B = d); an alteration of either d or λ would alter the cone angles. That was shown in the demonstration (mentioned on page 234 *ante*) by holding a glass plate powdered with lycopodium in the lantern beam; the light spot was surrounded by coloured rings. The particles had to be of very uniform size for this purpose, Professor Thomson remarked; when they were not uniform, the effect became indistinct, and of various powders he had tried, silica among them, he had found plant spores most suitable. A mist of water vapour or alcohol vapour, produced in a spherical bulb by expanding the vapour, showed these diffraction rings also; they were occasionally noticed on the Brocken spectre—when an observer saw his own shadow on the clouds—and men on flying machines had wonderful opportunities for such observations, of which he hoped records were preserved.

Each pair of electrons, Sir Joseph continued, then gave a curve like Fig. 2, or rings and, if ring systems intersected, spots. When we dealt with atoms we had many electrons, and we could only observe and calculate average effects. By analysis of the photographic records the effects of different pairs could be separated, however, and the different lengths d could be estimated. When four electrons were grouped at the corners of a square, the side of the square would be smaller than the diagonal, which also represented an A B in another direction; when the four electrons were at the corners of a tetrahedron, all the A B would be the same; thus the examination gave some clue as to the grouping of the electrons. As regards the number of electrons concerned, the suitable conditions for reliable calculations were more fully explained on the previous occasion (page 234 *ante*) to which we have already directed attention. The condition, that A B should be large by reference to λ, was not always heeded apparently in X-ray studies, the lecturer thought, and the absolute values obtained seemed doubtful for this reason. If all the electrons pointed the same way, the effect would be most brilliant. That, and the change of iridescence colours with the angle of incidence, could be demonstrated with ordinary light; Sir Joseph let the light of the lantern beam fall on some birds—a quezal, colibris, etc.—which were seen to shine in iridescent colours, brilliant green and blue, or dull greyish blue, according to the incidence. Specimens of mother of pearl and crystals of potassium chlorate, exemplifying the same effects, were on the table. When there were many electrons, it was not always possible, of course, to bring them into proper coincidence for reinforcement; but with proper d a series of spots would be obtained. The d here represented the side of the elementary cube of the space lattice of a crystal; Sir Joseph did not enter further into these points. To understand the problem, he said, one might think of a grating in three dimensions. Their effect could not be indicated by a drawing, but he could show what resulted when a ray of light fell upon two gratings so superposed in the same plane that the rulings of the one grating were at right angles to those of the other. Eight coloured light spots were then seen about the bright centre marking the incident ray; the spots were occupying the four corners of a square and four points half-way between the corners, and each spot was oval, the blue being turned inward, the red outward.

The difficult analysis of the X-ray patterns of spots obtained in crystal study, Sir Joseph proceeded, was generally performed by elaborate geometrical methods; but he had found a much more simple arithmetical method. That method resolved itself into finding three numbers, such that their squares summed up to the square of the given number. The number started from was the ratio of the side of the elementary cube, which represented the distance A B between the electrons, to the wave length, or d/λ. Suppose $d/\lambda = 5$, then $5^2 = 25$ might be expressed $5^2 + 0^2 + 0^2 = 25$, or $4^2 + 3^2 + 0^2 = 25$. Now each of the ratios $\frac{5}{5}, \frac{4}{5}, \frac{3}{5}, \frac{0}{5}$ represented a cosine direction of a spot, which was defined by the three cosines of one resolution on an orthogonal system of co-ordinates. Similarly $9^2 = 81$ might be resolved into $9^2 + 0^2 + 0^2 = 8^2 + 4^2 + 1^2 = 7^2 + 4^2 + 4^2 = 6^2 + 6^2 + 3^2$; in this case the cos were, *e.g.*, $\frac{8}{9}, \frac{4}{9}, \frac{1}{9}$. The order of the terms $\left(\frac{4}{9}, \frac{8}{9}, \frac{1}{9}, \text{ } e.g.\right)$ being immaterial, each of these resolutions gave six spots, unless two of the fractions were equal or equal to 0, when there would be fewer spots. The spot grouping was kaleidoscopic. If a spherical quadrant were drawn, then any point on the quadrant would produce six images with

respect to the planes bisecting the solid right angles —unless the point were lying on one of the boundary planes, when one of its co-ordinates would be 0; the whole sphere about a point would comprise eight of these quadrants, and there would thus be $8 \times 6 = 48$ spots (or fewer). Professor Thomson exhibited some of the original photographs of Laue, whose studies of the diffraction of Röntgen rays originated this study of crystal structure by X-rays, and also some which A. W. Hull had quite recently obtained.* The method of Hull, we may mention, resembles that which Debye and Scherrer† have used since 1915 in studying the structure of many crystalline substances and also of amorphous carbon, its advantages being that no crystals are required, but that particles of the finely powdered substance suffice which will be, and must be, in random arrangement. Debye forms small compressed cylinder of the substance; Hull places the powders in a small glass tube which he rotates about the longitudinal axis to which the beam of monochromatic X-rays is normal.

Concluding, Sir Joseph pointed out that the trouble was that the centre of the disturbance was supposed to be the atom, whilst the electrons were the centres, and though the arrangement of the electrons could be studied by using X-rays of different wave lengths, the difficulty remained that we had really to deal, so to say, with two sets of gratings: firstly, the grating, due to the arrangement of the atoms in successive parallel planes; and secondly, the grating formed by the electrons in the atom. Both these sets gave systems of spots. In some direction the two would coincide, and the electrons and atoms would conspire in the effect. That would not necessarily be a spectrum of the first order, however; it might be some spectrum of higher order, complicating the effects. He regretted that he had spoken of things that might be done rather than of things done; but there was little time for research just now.

LONG-RANGE ARTILLERY CALCULATION.

By SIR GEORGE GREENHILL.

RECENT events have directed attention forcibly to the importance of long range calculations in modern warfare, in opposition to the old-fashioned traditions of intellectual timidity and rule of thumb; and it is little consolation to the citizens who suffer under a distant bombardment to be assured it is of no military value.

Formerly the gunnery problem was presented to the student of theoretical artillery from a point of view the reverse of what is important to-day; from the data of given ballistic power of the projectile, and given muzzle velocity and angle of projection, he tried to calculate the range over a horizontal plane, the time of flight, angle of descent, striking velocity, and further, some subsidiary effects, such as drift from the vertical plane of fire; also the probability of hitting a target of given size.

In the field these details would be presented in a different order. The range would be given and then the requisite elevation looked out from a range table of the gun required to obtain this range, the ballistic power of the gun being given.

The old gunner preferred to make his own range table, based entirely on his practice, heedless of theory; but this method became too expensive with modern weapons, and ink was made to serve instead of gunpowder to a greater and greater extent in drawing up a range table, as more economical and equally trustworthy. But in our recent experience these conditions are reversed completely, and the former order of calculation requires to be turned round and inside out, and the problem considered in the reverse of the historical order. Suddenly we find one day the enemy shell begin dropping on us from the sky, and we cannot imagine whence they come, and calculation is our only guide.

Fragments pieced together tell us the calibre of the gun and weight of the shell. The slant of the hole made on impact in the ground gives the angle of descent, and the depth of the hole and other destructive effects are measures of the striking velocity. Working backward from these estimates, however rough, of the ballistic power of the shot, the striking velocity, and the angle of descent, and with the resistance of the air reversed in direction into an assistance, the usual calculations of long-range fire will determine ultimately the initial velocity, angle of projection, time of flight, and range of the shell, and then the gun is located within narrow limits, on the direction of the line of fire, corrected for drift and rotation of the earth. Because in a time of flight estimated as so great as $2\frac{1}{2}$ minutes, the influence of the earth's rotation is quite appreciable. It is calculated on the theory that the vertical plane of the trajectory remains fixed in space, as in the Foucault pendulum, and keeps pointing to a star near the horizon, rising or setting, while the horizontal plane on the earth is turning round at a horary rate of 15° at the pole, but 15° sin. lat. elsewhere; that is 15′ sin. lat. per minute of time (sidereal), or 0′·25 sin. lat. per second. Thus in 2·5 minutes, and in our latitude, the horizontal plane of the earth will have revolved about half a degree past the plane of the trajectory, and a deflection of 30′ must be given on the sight, against the sun, widdershins. In 75 miles, or 120 km., this would account for about 1 km. of deflection on Paris. The drift, too, of the shell fired from a right-handed rifling would require to be corrected by an additional deflection of considerable, but unknown amount, in the absence of an exact theory of drift, and determinable only by experiment. The total deflection reversed would be applied to the apparent line of fire into Paris, in locating the gun.

Acting on these preliminary instructions, our airmen will soon locate the enemy gun with accuracy, and endeavour to bomb it out, the target being too small to reach with distant gunfire. Meanwhile our artillerists must set to work to make up lost ground, and strive to produce a rival weapon of equal power, capable of imparting the requisite muzzle velocity to the shell of given weight; and here all the resources of calculation of internal ballistics and the theory of gun construction are required, before the gun can be designed and then put in hand in the workshop, everyone working hard against time. Any method of scientific procedure, however rough and ready, will be useful in saving time, and acting as a check on more refined calculation, and so we proceed to describe some such methods, given already in the writer's "Notes on Dynamics," for the use of the officers of the Advanced Class of the Artillery College, 1908, §78, page 99.

As stated there, "The parabolic theory of Galileo, although ignoring air resistance, is able to assign limits between which the real trajectory will lie in a resisting medium. The range X is supposed given, and the angle of departure and descent, α and ω; and then the real trajectory must lie between the two parabolas on the range X, with angles of departure α and ω, and equal angles of descent. The height h of the real trajectory lies between the height of the parabolas, so that $\frac{1}{4} \times \tan \alpha < h < \frac{1}{4} \times \tan \omega$. The time of flight T is intermediate to the parabolic times of flight,

$$\sqrt{\frac{2X}{g}} \tan \alpha < T < \sqrt{\frac{2X}{g}} \tan \omega.$$

And if V, v, denote the muzzle and striking velocity in the real trajectory,

$$V > \sqrt{(g X \operatorname{cosec} 2\alpha)} > \sqrt{(g X \operatorname{cosec} 2\omega)} > v, \text{ ft./sec.}$$

The least parabolic velocity to give the range is $\sqrt{(g X)}$, and then $\alpha = \omega = 45°$; and with a range of 75 miles, X = 396,000 ft., and $\sqrt{(g X)} =$ 3,200 ft. per second, a velocity attained by Andrew Noble in his experimental 6-in. 100-calibre gun, using a charge of 27·5 lb. of cordite, with a shot of unspecified weight, but probably 100 lb.

The height attained would be one-quarter the range, say, 19 miles, and the time of flight 157 seconds, a little over $2\frac{1}{2}$ minutes.

The actual time of flight has not yet been recorded, but we may assume for our argument that it was 2·5 minutes, making the average velocity over the ground for the 75 miles equal to 30 miles a minute, 1,800 miles an hour, 2,640 ft. per second. Suppose, then, we imagine a shot flying horizontally with this velocity, 2,640 ft. per second, 20 miles high, and calculate its history before and after.

At this height, and for a considerable distance lower, air resistance may be ignored in the absence of any appreciable atmosphere, although enough, as we see, to fire the meteorite; so we begin by calculating the advance of the shot on the parabolic theory while it has risen or fallen, say, 15 miles, before or after; and is still some 5 miles high above the ground. The time occupied in each of these movements will be about 70 seconds, so that the total horizontal advance is 70 miles.

We may suppose this parabolic trajectory raised on stilts 5 miles high, out of the region of appreciable air resistance, and then draw the supporting stilts at each end as the initial and final part of a real trajectory in the resisting air, first in a free-hand sweep to give some notion of the extra range at each end. The sweep of the curve must be flatter than the parabola and outside at the gun end, but inside and more curved where the shot is falling; and these are the two parts to be examined with greater care and attention to the dynamical equations with air resistance. The effect is to reduce the angle of elevation below 45°; but it is probable a greater elevation is given, say, 50°, or even 55°, to clear the lower dense strata, as pointed out in the "Text Book of Gunnery," 1904, page 225.

On the parabolic theory this would make the muzzle velocity greater than $2{,}640\ \sqrt{2} = 3{,}735$ ft. per second, so we may infer that a velocity is required in the region of 4,000 ft. per second. Sir Andrew Noble's gun must be lengthened again, by another 25 ft., to 150 calibres, to see if it is not possible to reach and surpass this 4,000 ft. per second velocity, and so produce a rival to the German long-range gun. Another increase of velocity of some 15 per cent., to 4,600 ft. per second, should increase the range some 30 per cent., from 75 miles to 100 miles, and then it would be possible to bombard London from Calais, the time of flight being about 3 minutes.

In the opinion of some experts the velocity of the present gun is from 5,000 ft. to 6,000 ft. per second, enough, in our opinion for a range of over 100 miles. According to French estimates the initial velocity would be about 1,400 metres per second, 4,600 ft. per second; and the weight of the shell is 100 kg. to 120 kg. This is rather light for the calibre 22 cm., 9 in., but enables the muzzle velocity to be increased, and the loss of driving power through the air is made up by fitting a long sharp-pointed Spitzer head of sheet iron, making the external appearance very similar to a modern rifle bullet $4\frac{1}{2}$ calibres long. The actual steel shell body is only a little over 2 calibres long, and the bursting charge in the cavity is divided in two by a diaphragm, with the object apparently of preventing a premature explosion during the discharge of the gun.

First accounts described the shell as arriving in two parts, and a theory was advanced that extra ranging power was obtained by an internal explosion about mid range. But as in the sharp-pointed rifle bullet, it is the scientific design of the exterior shape which gives the extra ranging power, with a diminished weight for high muzzle velocity.

The uncertainty in all these calculations of long-range fire is the estimate of air density in the upper strata of the atmosphere, discussed as a whole; a subject much debated in modern meteorology and geophysics.

Two assumptions are employed of this constitution, between which the true density of the air may be supposed to lie: (1) Isothermal equilibrium; (2) Convective equilibrium. These are discussed in the writer's "Hydrostatics," Chapter VII.

On the isothermal theory the temperature of the air is taken to be constant, and then the correction for the density of the air at a height y ft. is the tenuity factory $\tau = e^{-y/k}$, where k is the height of the homogeneous atmosphere, taken at ordinary temperature at 27,000 ft., say, 5 miles, but stretching or contracting with variation of temperature like an air thermometer. At this rate $\tau = e^{-1} = 0{\cdot}368$ at 5 miles high, so that air density and resistance is a little over one-third the value at ground level, and so could not be ignored. Airmen have flown at this height, or nearly. At 10 to 20 miles high,

* *Physical Review*, December, 1917, pages 661 to 696.
† See ENGINEERING, page 594, December, 1917.

$\tau = e^{-2}$, $e^{-4} = 0{\cdot}135$, $0{\cdot}018$, still appreciable, although small.

But on the convective theory the temperature is taken to diminish uniformly with the height y, according to the law $\frac{\theta}{\theta_\circ} = 1 - \frac{y}{c}$, connecting temperature absolute θ with ground temperature $\theta_\circ$; and $\frac{c}{k} = \frac{\gamma}{\gamma - 1} = 3{\cdot}5$, γ the ratio of the two specific heats of air, taken as 1·4.

According to this law, the tenuity factor

$$\tau = \left(1 - \frac{y}{c}\right)^{\frac{1}{\gamma - 1}} = \left(1 - \frac{y}{c}\right)^{3{\cdot}5}$$

and the atmosphere ceases at a height $y = c$, something less than 17 miles; and before attaining this height the temperature would be so low that the air would become liquid and frozen, and the shot would have to break the ice to reach a height of 20 miles. But this is in contradiction to the Twilight effect, or the height of the Krakatoa volcanic dust observed by astronomers. We conclude then that convective theory should not be employed beyond a limited height in the atmosphere.

If these artillery ranges go on increasing at the present astounding rate, we shall soon have to abandon the old parabolic theory of Galileo with a gravity in parallel lines; but take into account the convergence to the centre of the earth, and treat the shot as an independent planet or satellite by Newtonian methods, moving in the absence of air resistance in an elliptic orbit, about the centre of the earth at the focus. A geometrical investigation is given in "Notes on Dynamics," §94, page 118, taking a body projected from a Krakatoa volcano as illustration, or some of the dynamical conditions postulated in the romance of Jules Verne, as it was not anticipated we should ever see this fiction become the reality of our own time. The witty imaginary picture showing the shot that has missed London and gone round the world, in *The Bystander*, July 21, 1915, will no longer appear so highly impossible. The shot is depicted grazing the surface, and returning in 90 minutes or 80 minutes if girdling the equator, according as it moved eastward or westward; not in 40 minutes as Shakespeare's Puck, a velocity which would carry him away into space, unless held down by more than fourfold gravity.

NOTE.

ELECTRIC POWER SUPPLY AND COAL CONSERVATION.

THE report of the Coal Conservation Sub-Committee recommending the early construction of 16 super-power electric stations to supply the whole country [Cd. 8880] has naturally attracted much attention in the great municipalities which have already well-equipped plants. On April 12 we reported a speech of Mr. S. L. Pearce, the city electrical engineer of Manchester, in which the working expenses of a station situated on a river at a distance from the centre of demand were contrasted with those of a nearer station equipped with cooling towers, and therefore working at a lower thermal efficiency. The speaker showed that the cost of transmission was greater than the extra cost of coal, and that the proposed plan was, in that respect, inferior to that which they had adopted in Manchester. Last Wednesday, Mr. Ernest Hatton, the engineer and general manager of the Corporation Tramways and Electricity Undertaking of Newcastle-on-Tyne presented a report to the Parliamentary Committee of the city, in which he embodied his criticisms of the projected scheme. The Coal Conservation Committee had estimated the possible saving in coal following the adoption of their plan at 55,000,000 tons per year, and they naturally had directed much attention to the North-East Coast area, and particularly to the 11 waste heat stations which exist there. Mr. Hatton pointed out that electric-power distribution was already on a far greater scale on the North-East Coast than it was likely to attain in the rest of the country for many years, and then, taking that as a basis, he calculated the possible saving in coal. The plant on the North-East Coast is, according to the committee, one-ninth of the total plant in public supply stations in the United Kingdom, and its output is one-fifth of the whole. The saving due to the utilisation of waste heat is 150,000 tons of coal per annum. If this plan were in use everywhere the total possible saving would be 750,000 tons. But, Mr. Hatton pointed out, there is far more waste heat available in Durham than in any other area, and therefore this saving would probably not be realised. He added: "Assuming for the purpose of illustration . . . the low coal consumption of the power companies of the North-East Coast, and making an allowance of ½ lb. of coal average per horse-power-hour delivered at the consumers' terminals, we should then get 500,000 tons as representing the coal now consumed in excess of that which would have been the case had the power companies in this area supplied the whole output of the kingdom on the basis of the figures set out in the report. Adding this figure of 500,000 tons to the 600,000 tons of coal that would have been saved by using waste heat in the remaining four-fifths of the power supply of the kingdom, based on the North-East Coast figures, we get a total probable saving of 1,100,000 tons of coal, equivalent to 550,000*l.* per annum." This calculation appears to be based on the assumption that the demand will remain stationary, or nearly so. Mr. Hatton then went on to show that the new super-stations, in order to show any semblance of success during the present generation, would have to take over the existing power stations of local authorities and also those of electrically-equipped works in order to provide themselves with a demand, and he argued that the costs of transmission and conversion, and of writing-off the scrapped machinery, would about balance the economy effected by working on a large scale with modern plant. "Therefore, if the predicted saving of 55,000,000 tons of coal is to be made, it will not be from taking over the existing stations, but by modernising, *i.e.*, electrically equipping the works, manufactories, collieries, &c., in the country to receive the supplies from the proposed super-stations." The financial problems to be solved in the new scheme are more difficult than those of a technical nature. An immense change, such as that proposed, cannot pay from its inception, particularly if it is to act justly towards its predecessors. It has to create a demand by selling cheaply in the expectation of reaping its profits later. So far, power companies have not been conspicuous successes, largely on account of legislative restrictions imposed at the bidding of municipalities. It is to be hoped that in the future national rather than parochial prosperity will be considered, and in the meantime it is well that all sides should put forward their views, provided that the lobby of Parliament is not selected as the arena of conflict.

RECORDING SEA-WATER ALKALINITY.—Having placed platinum resistance thermometers, continuously recording the temperature of the sea water, and also instruments for the rapid determination of the density of sea water at the disposal of oceanographers, the Bureau of Standards, of Washington, has further devised an electrical instrument for recording the salinity of sea water on board ship. The instrument, described by E. E. Weibel and A. L. Thuras, in the *Journal of the Washington Academy of Sciences*, of March 19, 1918, is a Wheatstone bridge, in two arms of which two equal electrolytic cells A and B are inserted; A is sealed and contains sea water of a known salinity; the sea water examined is continuously flowing through B. The resistance ratio in the two arms is measured with the aid of alternating currents, in order to obviate the effects of polarisation and electrolysis. The two cells are placed in a temperature bath, through which the sea water is circulating, so that the error should be restricted to the small differential temperature coefficient of the two solutions. The probable error is not so insignificant as might appear, however. The current will always have a heating effect, and the sealed cell will more slowly adapt itself to changes in the sea water temperature than the open cell. Near Newfoundland a vessel going at moderate speed may pass through water currents the temperature of which changes at the rate of 3·5 deg. C. in 1 minute, for instance. But in general the changes in temperature and in salinity are slow, and the difficulty has been met by building up each of the two cells of six parallel glass tubes, 1 cm. in diameter, 14 cm. long; the tubes are arranged in a ring and joined to bulbular extensions containing the platinum electrodes; pockets in which air bubbles might settle are avoided. The recording mechanism is that of the Leeds and Northrup Company.

LITERATURE.

Welfare and Housing; A Practical Record of War-Time Management. By J. E. HUTTON. London: Longmans, Green and Co., 39, Paternoster-row. [Price 5s. net.]

THE war is responsible for much, and incidentally for the introduction of "physiological management" in preference to the phrase "Welfare supervision in factories." The latter is too limited to define the functions now aimed at. Originally the concept was to provide someone to control junior and particularly female labour, which was not possible under normal conditions in factories formerly run exclusively by male labour. Without entering into details it is obvious that male supervision was unsuitable, except for boys. The success of many of the operations of the welfare department in connection with boys and women has justified the extension of such departments to all male labour. But, unfortunately, there is, rightly or wrongly, an impression, due to the term "welfare," that the scheme partakes rather much of what may be characterised as Sunday school superintendence, and for this reason it is looked at askance by adult labour; in many cases, indeed, by female workers. It is well, therefore, that there should be a broader acceptance of the functions of this department, and Mr. J. E. Hutton, the manager of the Labour and Catering Department of Messrs. Vickers, Limited, attempts to introduce not only new phraseology by the term "Physiological Management," but a new atmosphere, which will be less open to the charge of undue interference than "welfare" and its application.

The aim of management of the individual is to contribute to the great desideratum of national efficiency, which requires not only the perfection of mechanism to ensure the highest output per unit of wage paid and full reward for effort exercised, but greater attention to the physiological condition of the worker. This involves a wide study of the conditions prevailing in the factory, in order that the worker shall be maintained in the best possible physique, and that those details shall be eliminated which are inimical to the full utilisation of physical effort with the minimum of avoidable fatigue. Under the former category there necessarily fall the questions of the hour of beginning operations, whether with or without a solid meal; the length of the working day; the provision of short rest periods; and the satisfactory heating, ventilating and lighting of the workshop or room. Beyond this there is the need for consideration of almost each individual unit. One of the instances in this connection quoted by Mr. Hutton is that the chucks of a row of lathes are often arranged at the same level, without consideration of the height, or the length of arm, of those who are to work them, and that the height for convenient work for a person of 5 ft. 1 in. cannot be correct for a person of 5 ft. 10 in. Again, he points out that it is easy to find, in connection with tables and benches, tall girls, with bent backs, working over tables, over which short girls, on the same bench, can hardly reach. The simple solution is footboards of sufficient height. Moreover, where convenient, tall chairs with foot rests should be provided, and on floors vibrating with machinery the legs of the chairs should be shod with rubber, to act as shock absorbers, while the backs of the chairs should be constructed according to the posture of the worker. Such considerations, while they seem specially applicable to female labour, cannot be ruled out of account even for male labour. Mr. Hutton gives a wealth of suggestion in small detail regarding all subjects which come under the term "physiological management." Indeed, the value of his book is due to the importance of such details, which are not readily quotable.

Where issue might be joined with him is in regard to the demarcation of responsibility between what we might term the "technical management" and the "physiological management." His view is that the engaging and dismissing of labour should be entirely with the latter, on the plea that their officials would be responsible for seeing that the workers come up to a certain standard of general health, mental and bodily activity and self-respect, and that when for any reason a worker gives notice

or receives notice to leave, the fact should immediately be notified to the physiological management, "who will then satisfy themselves of the necessity, and often succeed, by adjusting some slight personal grievance, in retaining the services of the worker." Herein lies the difficulty. Much depends on the *personnel* of both managerial departments, but we could conceive grave objection to the decision of the technical management being subject to review by the physiological management. The author admits that the question of wage should not belong to the welfare department, but that their officials should be thoroughly conversant with all systems of payment applied in the works so that they would be able at all times to explain to workers how their remuneration was arrived at, and, as far as possible, to smooth away any irritability or suspicion on the part of disappointed workers. At the same time he contends that they should keep a record of wages paid for each individual, as this is often an index of the physical state of the worker, which is the primary affair of the physiological overseer. The author attaches considerable importance to first-aid for accident and illness, and the chapter in his book which is communicated by Dr. Renton, the medical referee of the Vickers Company, is most suggestive, not only for special munition works, but for all establishments where consideration is given to the fitness of the worker.

No excuse need be made for enforcing the importance of this physical fitness, because it enters largely not only into the efficiency, but into the contentment and moral standing of the worker. These qualities, as we have already contended, are important items in the achievement of individual and national efficiency. We come, therefore, to the question of the degree of control and influence of management upon what might be termed the extra-mural work of the welfare or physiological department in management. Opinions on this question have expanded enormously during the period of the war. At one time workers were excessively suspicious of any movement on the part of management towards what they regarded as interference with life outside the gates. But, fortunately, there has been a great growth in what might be termed "tolerance"—perhaps an approach to sympathy—in the attitude of workers towards all such schemes. This is due in large measure to the enforcement of the view that all projects for bettering the condition of the people are based on economic and not on philanthropic considerations. For this reason, too, we commend the term "physiological management" rather than welfare work, because it differentiates between benevolence and economics. The housing of the worker must be improved if the best is to be got out of his physical potentialities; he must be well and suitably fed. On those two questions Mr. Hutton gives much valuable data for the guidance of others anxious to further these two desiderata. That he is qualified to guide is shown by one or two statistics of the work done by his department, and we may say, first, that—to quote Mr. Hutton's introduction, "the last thing in the world this volume is intended to be is a superfluous panegyric on one particular firm." The purpose achieved is to give complete analysis of the work done, of the difficulties overcome, and of cost and other data for the guidance of welfare departments.

We therefore quote some figures to show the extent of justification of the author's claim to write from a very wide experience. It is shown that the company employ 100,000 men. They have spent 1,000,000*l.* on temporary and permanent workmen's dwellings. At Barrow 610 cottages have been erected, with all the accessories of a model town included. At Crayford 589 cottages, on an estate of 50 acres, have been built, the cost for each being 350*l.* At Erith 400 cottages, on an estate of 40 acres, have been built at a cost of 376*l.* each. These mostly contain a living room, parlour, scullery, three bedrooms, with electric light, cooking by coal or gas, and a bath with fixed water supply; the rental varies from 8*s.* 6*d.* to 11*s.* per week. The houses are not more than 10 or 12 to the acre, and the windows of the living rooms have all a south or western aspect. In addition to this, the company arranged for the purchase of large private houses in North Kent over an area of 200 sq. miles, at a total rental of 23,000*l.* per annum, and these were divided into hostels. The furnishing of a hostel for 10 boarders and a staff of two, including kitchen and dining-room equipments, was 105*l.*, each cubicle costing for furnishing 6*l.* 7*s.* Details regarding the feeding from the central kitchens of all these, as well as the running of canteens in the works, are given with many helpful facts and suggestions. At one central hostel 2,500 lb. of bread and 70,000 pastries are baked per day. In the laundry 30,000 articles are dealt with per week. In one month the supplies for one of the kitchens cost 7,972*l.* 6*s.*, and in one canteen 100,000 meals were served.

It will therefore be accepted that Mr. Hutton writes with full knowledge, and the reader of the book cannot help realising that this knowledge is freely drawn upon for the guidance of other firms. There is a very sensible chapter on food values, which should be studied by all responsible for canteens. The view is taken that for sedentary work the daily requirement is 100 grammes of protein, and of fuel value 2,700 calories; for light work 112 and 3,050 respectively; for moderate work 125 and 3,500; for hard work, 150 and 4,500; and for very hard work, 175 and 5,500. It is interesting to find from the information given how the supplies at the canteens meet those conditions. The average protein per day was 146 and the average calories 3,695. The women, as a rule, take 25 per cent. less than the men. On the average, including bacon and sausages, the consumption of meat is nearly 1 lb. per day per man. In further indication of the fullness of the information, it may be said that a 33-h.p. 3-ton chassis char-a-banc used for transport of workers and food supplies, &c., in North Kent, costs for operation and management 16·45*d.* per mile, and the fuel consumption is equal to a gallon for 6·12 miles. The cost of tyres averages 0·1187*d.* per mile, a tyre press being fitted at the works, dealing with an average of 35 wheels per week for re-tyres. The subject is of great importance, and Mr. Hutton has done good service in placing so much data so freely at the disposal of those who are interested in the physiological condition of their workers.

BOOKS RECEIVED.

Aviation Engines. Design, Construction, Operation and Repair. By FIRST-LIEUTENANT VICTOR W. PAGE, A.S.S.C., U.S.R. London: Crosby Lockwood and Son.

Electricity Meters: Their Construction and Management. By C. H. W. GERHARDI, A.M.I.E.E. Second edition, revised and enlarged. London: Benn Brothers, Limited, *The Electrician* Offices, Bouverie-street.

Income-Tax and Super-Tax Practice. By W. E. SNELLING. Second edition, revised and enlarged. London: Sir Isaac Pitman and Sons, Limited. [Price 12*s.* 6*d.* net.]

Theory and Operation of Direct-Current Machinery. By CYRIL M. JANSKY, B.S., B.A. London: Hill Publishing Company, Limited. [Price 10*s.* 6*d.*]

A Dictionary of Aircraft. By W. E. DOMMETT. London: Electrical Press, Limited. [Price 2*s.* net.]

Department of Scientific and Industrial Research Report on the Sources and Production of Iron and other Metalliferous Ores used in the Iron and Steel Industry. London: H.M. Stationery Office. [Price 2*s.* net.]

Laxton's Builders' Price Book for 1918. Originally compiled by WILLIAM LAXTON. One hundred and first edition. London: Kelly's Directories, Limited. [Price 4*s.*]

What Industry Owes to Chemical Science. By RICHARD B. PILCHER, FRANK BUTLER JONES and SIR GEORGE BEILBY. London: Constable and Co., Limited. [Price 3*s.* net.]

Labour and Capital After the War, with an Introduction by the RIGHT HON. J. H. WHITLEY, M.P. Edited by S. J. CHAPMAN, C.B.E. London: John Murray, Albemarle-street. [Price 6*s.* net.]

The Book of the Ford. How Ford Owners can get the Best out of their Cars. By R. T. NICHOLSON, M.A. 3rd Edition. London: Temple Press, Limited. [Price 2*s.* net.]

The Motorists' Workshop; A Guide to Amateur Metal Work. Third Edition. London: Temple Press, Limited, Rosebery-avenue. [Price 1*s.* 3*d.* net.]

Clearing the Ground. By "LUMBERMAN." London: Constable and Co., Limited. [Price 7*s.* 6*d.* net.]

The Principles of Economic Geology. By WILLIAM HARVEY EMMONS, Ph.D., University of Minnesota. London: Hill Publishing Company.

Der Konizität der Radreifen und die Fahrt auf Gerarder Strecke Kinematische Studien uber die Bewegung der Eisenbahnfahrzeuge im Geleise. VON D.Sc.tech, U. R. RUEGGER. Zurich: Rascher and Cie. [3·50 francs.]

INDUSTRIAL NOTES.

THE Committee on Production recently considered an application for a bonus of 12½ per cent. on earnings made by various trade unions on behalf of their members, being building trade operatives, in the employment of firms who are members of certain employers' associations. By their award dated April 16, 1918, the committee granted from the first full pay after April 11, 1918, a bonus of 12½ per cent. on earnings to plain time workers and 7½ per cent. on earnings to piece workers engaged on constructional or maintenance work, such work being munitions work, carried out by employers in the building trade, whether as contractors or sub-contractors.

When the war broke out the total number of workshop canteens in existence was 100. To-day there are 840. In these canteens 2,500,000 principal meals are served every week. That is a substantial piece of social progress, which may be regarded as some set-off to the ghastly waste of war.

In the course of a letter to *The Times* of last Tuesday, Mr. Sidney Low states that "those who look for American aid to relieve us from our immediate difficulties should read the accounts of the proceedings in the United States Senate on March 27 and the following days. The Senate's Committee on Military Affairs took evidence from an officer in charge of the aviation programme. This officer testified that only one fighting aeroplane had thus far been sent from the United States to France. Senator New declared that of the 12,000 combatant planes which were to be delivered to General Pershing by July 1 not more than 37 will be deliverable by that time. Senator Lodge stated that only two cargo ships had been completed in the yards under the control of the United States Shipping Board. The same authoritative speaker said that, though the American War Department had spent six months in endeavouring to make an improved model of the French "75," it had failed to produce an adequate weapon, so that every gun in General Pershing's lines has had to be brought from a British or a French factory.

"As these statements and reports have been widely circulated in the American Press, I am conveying no information to the enemy by repeating them. But I think it desirable that they should be known and appreciated in this country, as they can be without in the least undervaluing the effort or the spirit of our friends beyond the Atlantic. . . ."

Mr. Low, as we all most emphatically do, rejoices in the moral support of the resolution of the American people, but adds that for months to come the burden of checking and defeating the Germans must continue to be borne by France and Great Britain.

Representative shipyard trade unions and the Shipbuilders Employers Federation met Lord Pirrie, at the Admiralty last week, when plans for the settlement of trade differences by local committees in shipyards were discussed. It was agreed that where possible all differences are to be settled in the yard in which the dispute arises by the usual trade machinery, and that Government intervention shall only take place in the event of the parties agreeing that the former method is unlikely to effect a settlement.

Speaking at a conference of the tanning and currying industry held last Monday, the 22nd inst., at the Leathersellers' Hall, to consider the formation of an Industrial Reconstruction Committee, Dr. Addison, the Minister of Reconstruction, stated that a sufficiency of raw material for industrial purposes after the war would depend primarily on the rapid provision of merchant ships. It would not be possible abruptly to cease all forms of Government control in respect of some commodities. It was necessary to secure the proper and sensible use of the tremendous facilities of the British Empire in respect of raw material supplies. With our Allies we had control of the great bulk of the essential raw materials of industry.

From information which he had obtained from the shipbuilding yards, he thought that the restoration of tonnage would be much more rapid than many people imagined. The only desire of the Government was to institute such methods as would conduce to the interest of the industries. The rapid turnover from war to peace was the first essential. Whatever nation got a good and early start after the war would promote its permanent prosperity enormously. Arrangements had been made by the Industries Committee dealing with priority questions to give new provisional priority when applications were made for the opening up of new industries, the desire being to encourage the industries to go ahead in preparing to take up work after the war.

Dr. Addison also spoke of the need for practical co-operation in our industries, and added that Germany had been able to make inroads into British commerce

through her financial, mercantile and other organisations, by means of which she had obtained detailed information of British enterprise in all parts of the world.

The Minister of Munitions has received the King's command to convey to the officials of the Ministry, to the employers, and to the men and women munition workers throughout the country, His Majesty's high approval of the exertions made during this critical time, his satisfaction at the high results achieved, and his thanks to all concerned.

Practically all the losses and expenditure of munitions during the battle have already been made good without any undue depletion of normal reserves, out of the resources which have been held in readiness and by the additional effort which has been made. There are actually now, the communication adds, more serviceable guns, machine guns and aeroplanes with the British armies in the field than there were on the eve of the German attack. The other supplies of all kinds are forthcoming in abundance.

We are informed that a recent communication from the Executive of the Amalgamated Society of Engineers to the branches of the society states the following: "It must be remembered that the cause for which our comrades are fighting overseas is one which the nation believes to be just, and any action which would tend to weaken the nation would be disastrous to the future of the working-class movement."

Speaking in London last Sunday, at a meeting of the National Society of Operative Printers and Assistants, Mr. G. L. Berry, the president of the American Pressmen and Assistants' Union, and a member of the American Labour delegation to this country, said that on behalf of 4,000,000 organised workers in the United States he was authorised to give a message of hope and encouragement. He stated: "You have got to stick it out at this momentous crisis and to hold out till America, who is heart and soul with you and your Allies, has got into her stride, which she will succeed in doing before very long."

Lord Furness presided at the ordinary general meeting of Irvine's Shipbuilding and Dry Docks Company, Limited, held in London on the 17th inst., and said it was very pleasing to notice that the representatives of the employers and workmen on the North-East Coast in the shipbuilding and allied industries had recently passed a joint resolution stating that "The industrial forces in the North-East Coast ordnance, shell and aviation shops, engine works, shipyards and ship-repairing establishments assure their comrades in the fighting line that they will do everything in their power to turn out in increasing numbers guns, shells, engines, ships and other munitions of war. Employers and workmen stand shoulder to shoulder determined to maintain and increase their efforts until complete victory crowns our arms." With this encouraging spirit animating our shipyard workers, he for one was not pessimistic, and felt sure that the shipbuilding industry of this country need not fear eclipse, even by our American cousins, who were putting such tremendous energy into the vital task of building ships in the present emergency.

With the object of bringing the company's plant into the highest possible state of efficiency, so that the available labour may be utilised to the greatest advantage, they were arranging to install the plant necessary to drive the whole of the machinery at their harbour yard by electricity.

The Minister of National Service issues the following statement as to the calling-up for military service of the older men who have become liable under the Military Service Act (No. 2), 1918:—

Instructions are being issued to recruiting officials that the necessary number of men of the new age are to be recruited in such a way as to avoid unnecessary disturbance in essential industries, provided an adequate flow of recruits can be obtained from among the younger men now exempted or protected from military service. The cancellation of exemptions in age groups in given industries or occupations by Proclamation or Order is not intended to preclude the recruiting of men above those ages in the industries or occupations affected, where the tribunals consider that they should be made available for military service, and the extent to which such men are made available will proportionately reduce the call that has to be made upon the older men.

(1) It is not proposed at present to call up for service or even for medical examination men of the new military age who are registered as engaged in agriculture, Government constructional work, *e.g.*, aerodrome construction, mines, munitions, railways and transport, shipbuilding. (2) The protection afforded by the present List of Certified Occupations R. 136 extends to men of the ages now made liable to military service, if they are engaged in one of the occupations specified. (3) Men of the new age will be called up for medical examination by age groups. The first group will include the men born in 1874 and 1875. (4) No man will be called to report for service until after he has been medically examined; and every notice calling-up an older man for service will give 14 days' notice of the time and place at which he is to report. For the time being, men of the new military age will not be called up for service unless in Grade 1 or Grade 2. (5) Every man of the new age will have full opportunity of exercising his tribunal rights. Particular care will be taken by National Service Representatives appearing before tribunals to see that full consideration is given to cases of directing heads of businesses, and key men of working staffs. (6) Special instructions will be issued containing directions as to the medical examination of the older men. (7) Subject to military exigencies the corps to which the War Office propose to post the older men are: (*a*) Combatant service—Home Defence Infantry, and Garrison Battalions at Home and Abroad; Royal Field Artillery, and Royal Garrison Artillery at Home. (*b*) Auxiliary services at home and abroad, such as Royal Army Medical Corps, Army Service Corps, *e.g.*, Motor and Horse Transport, Remounts, Supplies, &c. Army Ordnance Corps, Veterinary Corps, Inland Water Transport and Dock, Railway Troops, Roads and Quarries. Such men will also be posted to the Air Force for duty with the squadrons. Men of the older ages who are called up and have the necessary qualifications will have the usual opportunities of becoming officers in the various services in the Army for which they are suited. (8) Special instructions will shortly be issued dealing with duly qualified medical practitioners. (9) Notices calling up men of the new age for medical examination are being prepared from information available on the National Register. Particulars have in many cases not been furnished to the local authorities concerning men who patriotically volunteered for service and actually served in the armed forces of the crown since August 15, 1915. If calling-up notices should inadvertently be sent to such men, full particulars of the unit, corps or branch of the forces in which he served or is serving should be given on the back of the notice, which should be returned to the office of origin. This will enable the registers to be corrected, and will obviate inconvenience to the addressee's relatives and friends.

A number of instances have occurred recently where men employed on work for which the age of protection under the Schedule of Protected Occupations is high have moved to other work where the age is lower, in the hope of evading military service. The Minister of National Service draws attention to the fact that the schedule excludes such men from protection, since the lower age only applies to men engaged on work on or before the dates indicated in the schedule, for instance, January 1 in the case of shipyards. Steps are being taken in accordance with the schedule to call up such men for military service from the works to which they have transferred.

In a letter to *The Times* of last Tuesday, Dr. H. M. Vernon, of Magdalen College, Oxford, says it is universally agreed that at the present moment shipbuilding is the most important industry in the country, and it appears that all men engaged upon it, whatever their age, are to be exempted from the Army. Though such exemption may be necessary, it surely carries strict obligations with it. A man ought to be allowed to retain his privileged position only if he works well, and yet we find that in some of the shipyards there is an excessive amount of slacking and bad timekeeping. In one of the largest and most reputable of our shipbuilding firms he has been making inquiries for the Health of Munition Workers' Committee, and finds that, though the men in the engine works keep good time, many of the men in the yards do quite the reverse. The riveters are the worst, and figures show that in February and March of the present year 26 per cent. of the journeymen riveters (*i.e.*, those who have served their full apprenticeship) missed their before-breakfast work (6 to 9 a.m.), and 9 per cent. of them were absent for the whole day.

But worst of all were the apprentice riveters, for on an average they missed more than one whole day of work every week, besides missing before-breakfast work on another day. This was not because they were working long hours, as it was very seldom indeed that they were called upon for more than their normal 54 hours per week. In September-November, 1916, when they did work overtime rather more frequently, they stayed away for two whole days a week, and missed their before-breakfast work on another day. These apprentices are mostly young men of 16 to 22, who easily earn more money than they know how to spend, and so do just as much or as little work as they feel inclined to do. Such a condition of affairs is outrageous at the present crisis, and it is to be hoped that the Director-General of National Service will lay down a rule that no man engaged in the shipbuilding and other protected trades can claim exemption as a right. He should retain the privilege only so long as he works well and keeps good time, and failing this he should be drafted into the Army. If, after due warning, a small number of the worst offenders among the apprentice riveters were taken off in this way, the moral effect upon the rest of the shipyard workers would be so great that their time-keeping and output would be certain to improve in greater proportion than would correspond with the labour lost by the withdrawals. In other words, the total output of the shipyards would be improved, while the Army would obtain a number of recruits in addition.

Three meetings, attended by practically the whole of the adult workers in the employment of Messrs. Cammell Laird, Birkenhead, have been addressed on the need for increasing the output of ships by Sir George J. Carter, K.B.E., the managing director. About 3,000 were present at each of the meetings. Sir George said it was urgently necessary that the management and the men should closely co-operate in this time of crisis in order to attain the greatest possible output of new tonnage and the utmost speed and efficiency in the repair and refit of both naval and merchant vessels. He added that it was the united desire of both employers and men that all matters relating to labour in shipyards and marine engineering works should be brought under the administration of one Government department, and that such questions should only be dealt with by that department after the duly appointed representatives of employers and employed had failed to arrive at an agreement. He strongly advocated the introduction of a shorter working day, in order that men might have leisure for rest and recreation and for education in its broadest sense. In this time of national peril there was, of course, no question of shorter working hours. The need was for maximum production and longer hours But he hoped the time was not far distant when the employers, through their organisations, and the men, through their societies, would meet together and mutually agree to shorten the working hours. He had always been a believer in organised labour.

TRAINING OF MOTOR VOLUNTEERS.—There are still a number of vacancies in Group No. 1 of the City of London Motor Volunteer Corps both for motor drivers who have their own vehicles and other drivers who are willing to enrol as spare drivers as occasion arises. In view of the new regulations making it compulsory for all exempted men, in future, to join the Volunteers, an excellent opportunity is afforded to motor drivers to fulfil this condition. There is no subscription to the Corps, and the number of drills required to be performed is not excessive. Full particulars can be obtained from the Adjutant, Group No. 1, Captain F. G. Bristow, at the Headquarters, 83, Pall Mall, S.W. 1.

USE OF SOAP FILMS IN ENGINEERING.—That the fascinating study of soap films has its practical utility had been pointed out by Sir James Dewar in the course of his Royal Institution discourses on soap films, and last Friday Sir James, in the same place, listened to a lecture on one of the ways in which this study helps the engineer to solve difficult problems. Major G. I. Taylor was discoursing on "The Use of Soap Films in Engineering," explaining the use of soap films in solving torsion problems, a subject which he, in conjunction with Mr. A. A. Griffith, had brought before the Institution of Mechanical Engineers in December last (see ENGINEERING, December 21 and 28, 1917). In his introduction Mr. Taylor demonstrated the nature of torsion problems with the aid of cylindrical rods of high elasticity, made out of a preparation of gelatine, glycerol and soap. Straight lines, parallel to the longitudinal axis of the cylinder, and circles representing normal cross section, were drawn on the cylinders, and it was shown that the squares thus formed were changed into rhombic figures when the rod was twisted, that the stresses were both lateral and upward and downward, and that an overstrained cylinder would break in a plane, approximately at 45 deg. to the axis. When the cross section of the rod was circular, the curves of equal stresses were concentric circles. In an elliptical rod the elliptical curves were more crowded in the direction of the minor axis than in the direction of the major axis. This seemed contrary to expectation. It was demonstrated, however, that in the case of an elliptical rod the cross section of the twisted rod did not remain plane, but was distorted out of the plane, so that the direction of maximum strain was displaced. As regards the mathematics, Major Taylor mentioned one fact underlying his method, to which he had not referred in his paper before the Institution of Mechanical Engineers. It had been proved by Fraenkel, of Göttingen, he said, that the equations of St. Venant, representing the torsion of an elastic bar, were exactly of the same form as those which represented the displacement of a soap film due to a slight pressure acting on its surface, the film being stretched over a hole in a flat plate of the same shape as the cross section in question. The slight difference in air pressure, which produces the displacement of the film, need not be determined, as was pointed out by the investigators in the original paper.

THE CANAL QUESTION.

To the Editor of Engineering.

Sir,—A letter appears on page 438 of your issue of the 19th inst., signed "Punter," in reference to the canal question.

Whilst "Punter" apparently knows something of the financial condition of canals in France, we think he looks upon the use of the Thames by commercial craft, if not from a biassed, at least from a superficial, point of view.

From the *nom de plume* we imagine that when he has been on the river he has been more interested in the scenery than the commerce of the nation, otherwise he would know that there is a considerable traffic on the Upper Thames in commercial craft. That he so vaguely refers to the tonnage carried by Upper Thames barges seems further to prove that his knowledge is superficial. Practically all the barges working the Upper Thames are capable of carrying only about 100 tons as far as Reading and 60 tons up to Oxford, which is again reduced in those barges which are fitted for towing purposes by about 40 tons. It is not probable that if the canalisation of the Upper Thames was carried out in such a way that it permitted reasonably large-sized barges and deep-draught tugs to navigate above Teddington right through to Oxford the volume of merchandise carried would be very considerably increased, because the type of barge and tug used in the Lower Thames could then carry goods right through without trans-shipment.

We think the point of the canal question is that the cheapest means of transport should be encouraged, whereas it is very seldom indeed that a vessel makes a passage from Teddington to Oxford without some complaint being made by punters taking their ease who object to the slight noise, unavoidable smoke and even the sight of commercial craft; in other words, commercial craft use our big highway above Teddington on sufferance, and the complaints unfortunately arise mostly from the idlers.

Yours faithfully,
(For Perman and Co., Limited),
Perman, Managing Director.

82-83, Fenchurch-street, London, E.C.,
April 24, 1918.

ELEMENTARY ECONOMICS AND THE EDUCATION BILL.

To the Editor of Engineering.

Sir,—In my letter, published in your issue of the 19th inst., were outlined as briefly as possible the three fundamental obligations upon fulfilment of which depend the existence and prosperity of every community or nation. But there are also circumstances peculiar to every nation which have to be considered when devising any scheme of National education. In this country these are:—

1. A burden of debt amounting to about 200*l.* per head (assuming pensions to be capitalised) on every man, woman and child in the United Kingdom.

2. A great number of the young and best men who should have been the fathers of the coming generation are killed, and a still greater number crippled and unfit to maintain, unaided, the struggle for existence.

3. A very great number of young women, potential mothers of the next generation, whose mates have been killed, and who must work for their living in competition with the surviving men, in occupations hitherto reserved by men for themselves.

These abnormal and unhealthy conditions will be still more acute on the Continent of Europe, especially in the Central Empires, which are already full of starving women and children, clamouring for food and ready to work any length of time at any wage that will keep soul and body together. Competition to live, which means competition to sell, will be fiercer and more bitter than it has been for centuries, for all the white races will be, in greater or less degree, similarly burdened. It is inevitable that the young men and women of the present and future generations will have to live and work under these conditions, and if they are to survive must be so educated as to work successfully and profitably under them. Youth here must begin to work early for two reasons. Specialisation, or proficiency and skill, in most trades can only be taught and acquired early, and men and women in other countries will begin in early youth to compete with us here for their living. The problem before any body of men trying to devise a system of national education is to reconcile it to the three fundamental economic laws and to the onerous conditions of life which prevail now, and will become heavier in the future.

Education must not be made so heavy a tax on either the community, or the parents, as to be the cause of restriction on production of children. It is a fact established by observation and statistics that in countries, or classes of society, in which children are a burden, population is stationary or declining, and that when children are permitted to help their parents at a comparatively early age it increases. No European, no white race, will be rich enough to keep its youth unemployed, or partially employed beyond 14 years of age, for many generations to come. The country which tries the experiment will institute national suicide disguised as national education.

Strong inducements must be offered to parents to bring to useful maturity large families of healthy children, and this can be done only by making the children an asset to the parents, without at the same time permitting them to exploit the labour of their children. One very strong inducement would be to make the children contribute to the old-age pensions of their parents. The pensions of bachelors should be reduced to a minimum or even nothing at all; and employers should be compelled to collect from the children a small proportion of their earnings which would be paid in, through a card, to Government towards the pension of their parents. The more children, the bigger the pension, for these contributions by the children would be for the benefit of their own parents only.

Every girl should complete her studies with a course of domestic economy and the management of children. No community is healthy, nor does the population increase, in which there is a surplus of unmarried women and competition for husbands, therefore the young women of this country must be so trained as to be desirable and valuable helpmeets to men in the Colonies and abroad where there is a surplus of unmarried men.

It is the experience of teachers of pupils from all classes of society, that only a very small proportion of the boys and girls are capable of benefiting by attendance at school beyond a comparatively early age. Brains are much more difficult to breed than bodies. School teaching quickens the brain up to a point which is reached in most cases very early, and deterioration results from keeping such pupils at school or college till near maturity, for they learn idle habits and become more or less polished and accomplished loafers, work-shy and waiting for a genteel occupation. On the other hand, it will usually be found that the great majority of pupils are strong on one subject or trade, and if developed in the direction of their natural bent become useful and successful members of the community.

Lastly, for the preservation, security and prosperity of the community every young man, without exception, should be a trained fighting man, fully equipped and ready to step into his place in his appropriate military unit. All this can be done without raising the age for leaving school, or increasing the burdens on the parents.

What is required is a combined system of civil, technical and military education, a system that will turn out specialised men and useful women, not young people crammed with odds and ends of general information and knowledge which are of no particular use to them, and which are very appropriately called "general education." It is because the teachers have been compelled to dispense "general knowledge" to every patient, no matter what kind of mental strength or weakness he enjoyed or suffered from, that our present system has failed. Why aggravate its defects?

At present, in most schools, the classes are far too large and the teachers are unable to give individual attention to their pupils, or to study their characters as they should. More teachers and smaller classes are required, and to attract the right class of men and women, higher salaries and better pensions should be offered. Mr. Fisher's recommendations on this point are sound.

As regards the children, the example of Sweden and Norway should be followed and more time devoted to physical training. In Board Schools generally, too little time is given to systematic scientific development of the growing body. On entering school every child should be required to produce from a competent doctor, a form, specially prepared for the purpose, giving full details of weight, measurements, condition of eyes, teeth, vital organs, and of any malformations or defects which are very common and usually amenable to appropriate treatment in early youth.

It would make too great a demand on your space to elaborate the details of a system of ordinary school education combined with technical and military training, which would be continued after leaving school at 14. It is quite simple, practical and inexpensive. It gives every boy and girl who has sufficient capacity and power of concentration and application an opportunity of rising in life, and it fits those who have not the brains to become foremen and leaders, to be useful citizens. It would also turn out men trained and ready, fit to take their places in the ranks at any time.

This scheme was fully detailed in Engineering of August 13 and 20, 1915, and was approved by leading practical men, as well as school teachers. It will not appeal to the advocate of general education who apparently believes in trying to turn out "all-round men," a kind of putty or plasticine creature who can be squeezed comfortably into any kind of opening, and fill it more or less satisfactorily. The opening might be filled to the satisfaction of the occupant, but whether the work would be well done is not by any means so certain.

Yours faithfully,
Peter Swan.

April 22, 1918.

THE MILITARY AUTHORITIES AND ENGINEERS.

To the Editor of Engineering.

Sir,—The lucid way in which "Suum Cuique Tributo" exposes the *laissez-faire* policy of the Institution of Civil Engineers in not adequately safeguarding and upholding the interests of its members, will appeal to many corporate members of the Institution, who feel that this body, representing the cream of the engineering profession of the British Empire, and seemingly accepting that position of pre-eminence in other matters, has so singularly failed to uphold the status of many corporate members who are serving the State to-day.

Other professional bodies with no higher credentials have, by the exercise of firmness and tact, secured for their members a status which it is universally conceded their value to the State demands.

This is unfortunately far from being true of many corporate members of the Institution, who, before and during the present war, have steadfastly endeavoured to serve their country, and uphold the highest ideals of the profession in all matters pertaining to engineering generally.

It is felt by a large number of its corporate members that it is time that the Institution of Civil Engineers, if it really desires to maintain and uphold not only its premier position among engineering institutes, but its position in the front rank of professional associations, should take immediate steps to secure the full professional recognition of its members in Government service, and that they are accorded the same status and privileges accorded to other professional bodies, including military officers, whose importance to the welfare of the State is in no wise greater.

Many corporate members feel that the Institution has largely failed to uphold their position, and that it is time, assuming that the Institution is not prepared to press the urgent and just claims of its members with more vigour than in the past, that they join forces and form a professional association of British engineers, which will consider the interests of its members in exactly the same way that the British Medical Association safeguards the position of the physician and surgeon. We enclose our signatures and are,

Yours faithfully,
"Eighteen Corporate Members."

April 18, 1918.

ELECTRICITY *VERSUS* GAS AND COAL FOR DOMESTIC USE.

To the Editor of Engineering.

Sir,—Until recently it had to be admitted (1) as regards illuminants that incandescent gas lighting was a little cheaper than illuminating by electricity, (2) as regards heating, that coal fires were cheapest, (3) as regards cooking that gas fires were the less costly, and (4) as regards heating water that nothing would compete with a coke-fed boiler.

With electricity, though produced under the most approved conditions, no such concessions would be necessary for electricity is and can be produced so that nothing can compete with this source of energy when all considerations are taken into account. The most approved conditions of production of electricity is carbonising coal fed into retorts for production of gas at a certain caloric as has been found best for production and abstraction of various residuals and burning such gases for generation of steam for electrical energy.

The value of the abstracted residuals alone is worth more than the coal consumed, so it may easily be conceived how the claim above-made is true.

Other considerations which have, and always must be, conceded in favour of electricity as compared with direct burning of gas, coal or oil are (1) more hygienic, (2) more safe, (3) less wear and tear, (4) less renewals and cleaning, (5) less shrinkage in roasting of meat of about 25 per cent.

Can any of your readers give particulars as to the best kind of retorts for carbonising coal for production and abstraction of residuals and producing gas for boilers as referred to above?

Yours faithfully,
A. A. J.

April 12, 1918.

AIR PUMPS.

To the Editor of Engineering.

Sir,—I am much interested in Mr. Edwards' letters *re* "Edwards'" air pumps in your issue of this week and of October 12, and I should be much obliged if he can say how the horse-power required for different sizes of "Edwards'" air pumps can be calculated. I remember seeing, a few years ago, a diagram giving the horse-power required for different sizes and speeds of air pumps; and if Mr. Edwards could give such information, it would, I am sure, be of great interest to many of your readers, as well as to myself.

With regard to the indicator diagram, Mr. Edwards does not say where the indicator was connected to the air-pump casing. Apparently the indicator was fixed to the end of a pipe. If the indicator had been fixed directly to the air pump barrel a different diagram would probably have been given. It would be of great interest if Mr. Edwards can give a diagram showing correctly the pressures in an "Edwards'" air pump; and also if he can say what horse-power was actually required to drive the pump.

Yours faithfully,
S.

April 20, 1918.

LONG-RANGE GUNS.

To the Editor of Engineering.

Sir,—It is doubtless true that high chamber pressure in a long-range gun means thick-walled shells with but small bursting charges.

But why need the chamber pressure be so high? Would not a longer gun permit the use of lower and longer-maintained pressure, thin-walled shells and big bursting charges?

Yours faithfully,
W. J. T.

The German Dunlop Company.—The affairs of the German Dunlop Company at Hanau have not improved under their present German management. It was first placed under compulsory German administration, and afterwards the shares were sold to the Adler Motor Car and Cycle Company, and the Opel Company, half to each firm, when the compulsory administration ceased. The profits on business last year amounted to 156,496 marks, against 2,640,822 marks the previous year, the loss on last year amounting to 1,190,386 marks, against profits amounting to 845,992 marks the previous year.

THE CONTROL OF LARGE AMOUNTS OF POWER.*

By E. B. WEDMORE, Member.

(*Concluded from page* 443.)

APPENDIX IV.

CURRENT-LIMITING BY THE USE OF BUSBAR REACTANCE.

THE question is how far in the system generally can the short-circuit current be controlled by the use of busbar reactance in the generating station.

Fig. 15. REDUCTION OF SHORT-CIRCUIT BY THE EMPLOYMENT OF REACTANCES INCLOSED RING

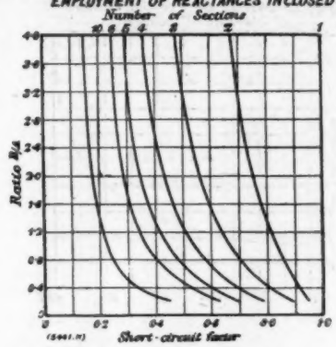


Fig. 16. REDUCTION OF SHORT-CIRCUIT WITH STAR DESIGN

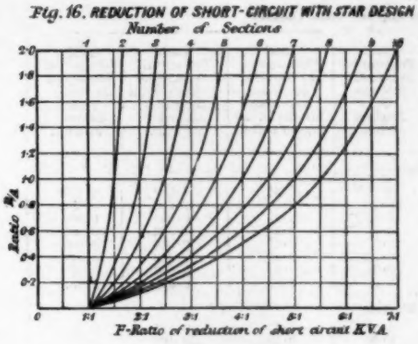


Fig. 17. COMBINATIONS OF MACHINES REQUIRING MAXIMUM TRANSFER CAPACITY

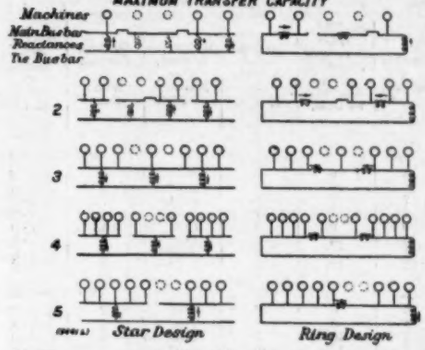


Fig. 18. COMBINED EFFECT OF GENERATOR AND BUSBAR REACTANCES, STAR DESIGN WITH 2 & 5 SECTIONS

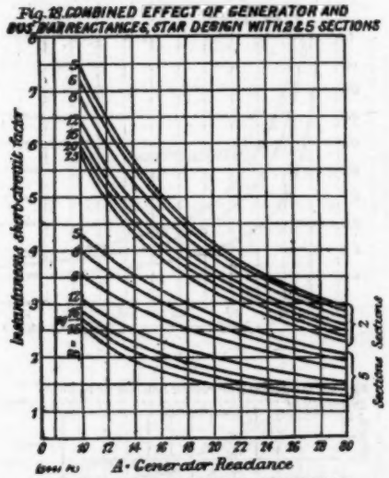


Fig. 20. COMBINATIONS OF B AND A GIVING EQUAL PROTECTION, STAR DESIGN, WITH FIVE SECTIONS

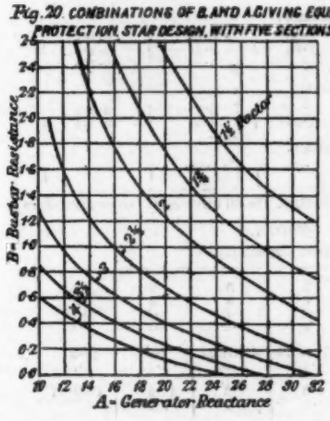


Fig. 19. COMBINATIONS OF B AND A GIVING EQUAL PROTECTION, STAR DESIGN, WITH TWO SECTIONS

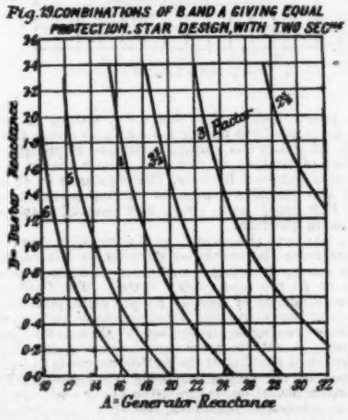


Fig. 21. TRANSFER CAPACITY OF REACTANCES (STAR DESIGN)

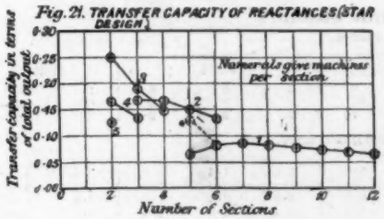
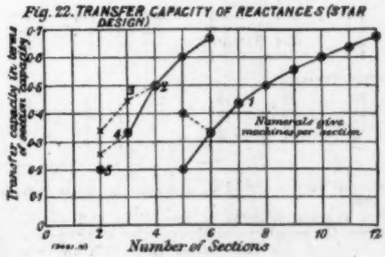


Fig. 22. TRANSFER CAPACITY OF REACTANCES (STAR DESIGN)



The value of the short-circuit current depends upon five variables :—

(a) The working voltage.
(b) The total generator capacity.
(c) The generator reactance whether internal or external.
(d) The busbar reactance.
(e) The number of busbar sections.

The results obtainable may be reduced to a single diagram, using the short-circuit current obtainable without busbar reactance as a unit. This is readily ascertainable as follows :—

$$\text{Short-circuit k.v.a.} = \frac{\text{Total generator k.v.a.} \times 100}{\text{Percentage generator reactance}}$$

Taking this as the unit, Figs. 6 (page 441 *ante*) and 15 show the reduction with different values of busbar reactance "B" expressed in terms of the generator reactance "A" and for different numbers of busbar sections.

Fig. 6 represents the star design and Fig. 15 the closed ring design. In the latter, current is fed from both sides so that reactances are required of about twice the ohmic value for the same degree of protection. In Fig. 15, therefore, the vertical scale has been doubled, and with this alteration it will be seen that the two sets of curves are very similar.

In Fig. 6 from the bottom of the diagram it is evident that the introduction of a small amount of bus bar reactance has a big effect in reducing the short-circuit values. As the reactance value is increased, its effectiveness by no means increases proportionally. The same is true of increasing the number of sections. The curves are figured from the following formula, giving the factor *f*, that is, the ratio between maximum short-circuit currents with and without reactance :—

$$f = \frac{(N-1) + \left(\frac{B}{A}N + 1\right)}{N\left(\frac{B}{A}N + 1\right)}$$

where A = generator reactance.
B = busbar reactance.
N = number of sections.

The results are shown in a different form in Fig. 16, the horizontal ordinates in which are the inverse of those in Fig. 6. It will be noticed that the factor *f* has equal increments for each additional busbar section.

These curves are based on the assumption that the full complement of generators is connected to each busbar section, whereas the worst case in practice is shown in Fig. 17. Separate curves would be required for each case there shown. The above curves give results a little on the high side if the total generator capacity is taken as a basis, and on the low side if the maximum of machines running on maximum output is taken as a basis.

These curves cover the ground of what is practicable, as it will be shown later that the amount of busbar reactance permissible is limited by the permissible voltage difference between busbar sections, and that in the endeavour to keep down short-circuit stresses the increase of generator reactance will keep down the ratio well within the range of the above curves and within economical limits. These are the factors which will be found to determine the cost, but a few words may be said here on the question of the best value of the ratio B/A from the cost aspect.

We have to consider the total protective value obtained with generator plus busbar reactance, and this is indicated in Fig. 18, in which the vertical scale gives the number of times the short-circuit current exceeds the normal output of the machines. It should be noted that these curves are figured on the total plant capacity and not on the maximum output of the plant. They show the ratio for two and for five sections and with different values of busbar reactance.

Based on these, Figs. 19 and 20 have been prepared showing different combinations of generator and busbar reactance giving equal protection.

So long as the generator reactance can be provided internally the cheapest combination will be that with minimum busbar reactance, but even if all necessary protection of plant could be obtained with generator reactance alone it would still pay to employ busbar reactance owing to the protection afforded to continuity of supply.

In case some of the reactance is put external to the generators there will be a value of B/A giving minimum cost. This ratio can be varied over wide limits without materially affecting the cost, and the best figure depends upon how much reactance is external and upon the number of busbar sections and transfer capacity required. As a rough guide it may be said that for five busbar sections the minimum is reached when B/A is in the neighbourhood of unity, and with two sections when B is 1/3 A, but either ratio may be varied by two or even three to one without seriously affecting costs, so here again we have to look to technical grounds for our limiting features.

APPENDIX V.

TRANSFER OF LOAD THROUGH REACTANCES.

The conditions requiring the largest load transfer with different numbers of machines per section are illustrated by Fig. 17. The relation between the generator capacity tied to a section and the maximum load on that section is scheduled overleaf on the basis of machines of uniform size and of two spares. In practice one has to deal with unequal sections and machine capacities, but one aims at equal sections and generator capacity per section, two small machines counting as one large one. The spares of largest size are the principal determining factor, so that the conclusions drawn give a good idea of what is required and indicate the basis on which individual cases should be worked out.

Referring to Fig. 17, the diagram for two machines per section is typical. In this, the worst case occurs when the station is fully loaded, i.e., all but the two spare machines are running, and the two machines shut down are on the same section. The section is tied solidly to the adjacent section, forming one section

* Paper read before the Institution of Electrical Engineers.

with two machines directly connected, this being the permissible maximum. One reactance is also cut out, so that the doubled section is properly protected by a single reactance.

The conditions shown in the figure will arise not only out of necessity, but also out of convenience in the normal operation of the plant, and should be met by the provision of ample carrying capacity in the reactance, rather than by special switching operations involving the use of the auxiliary busbar.

Schedule A gives the transfer capacity for the star design for each of the cases illustrated. On referring to Fig. 17, and to the diagram for the ring design, it will be seen that the transfer capacity in the first figure must be the same for both ring and star design. In the remaining cases in the ring design the transferred load is divided between two reactances which so long as the ring is closed could therefore have half the current capacity. On the other hand, if the ring is broken, as it is bound to be from time to time, then in the worst case one reactance must carry the total transfer as in the star design. This worst case is most likely to happen if there are only two busbar sections, and will happen in the other cases if we have two machines on one section down and need to shut down an adjacent busbar at full load, a rather unlikely contingency. If this case arises and is not provided for, then we shall be compelled temporarily to cut out reactance or operate with excessive potential difference.

With the ring design a compromise can be effected by allowing, say, three-quarters of the capacity shown for the star design.

A study of Fig. 21 will bring out the meaning of the data scheduled.

It will be noted that for a given total output and number of machines per section, the transfer capacity required does not vary much with the number of sections. The falling-off would be compensated if with the larger number of machines more than two spares were provided. It should also be borne in mind that the figures are based on one size of machine throughout, whereas on some sections, and especially the first installed, there will be an equivalent capacity made up of smaller machines. These require less transfer, so that in actual conditions the capacity required is practically determined by the final total output aimed at, and must be made sufficient for this.

For a given amount of protection and number of sections, the number and ohmic value of the reactances are fixed, so the cost varies only with the transfer capacity. These curves therefore give a good idea of the relative cost for different numbers of machines per section. It will be seen that one machine per section gives the lowest cost, but in some cases with an impracticable number of sections.

Further calculation shows that the cost of the reactances for a given measure of protection decreases with an increase in the number of sections, but on the other hand the cost of the necessary switchgear for the larger number of reactances is increased, and investigation of two typical cases indicates that the balance is negligible. It is clear, therefore, that in considering the best number of sections to employ, the question of cost of the reactance equipment is not a guiding feature.

SCHEDULE A.

TRANSFER CURRENT CAPACITY OF REACTANCES: STAR DESIGN.

Number of Sections.	Total Generator Capacity, One Machine as Unit.	Maximum Total Output, Two Spares.	Output per Section, One Machine as Unit.	Sections Coupled in Worst Case.	Output of Coupled Sections, One Machine as Unit.	Load Transferred to Coupled Sections, One Machine as Unit.	Load Transferred to Coupled Sections, Generator Capacity of One Section as Unit.	Load Transferred to Coupled Sections, total Generator Capacity as Unit.	Load Transferred to Coupled Sections, Total Output as Unit.
				ONE MACHINE PER SECTION.					
5	5	3	0·60	2	1·20	0·40*	0·4*	0·08*	0·133*
6	6	4	0·67	2	1·33	0·33	0·33	0·055	0·083
7	7	5	0·71	2	1·43	0·43	0·43	0·061	0·086
8	8	6	0·75	2	1·50	0·50	0·50	0·062	0·083
9	9	7	0·78	2	1·56	0·56	0·56	0·062	0·080
10	10	8	0·80	2	1·60	0·60	0·60	0·060	0·075
11	11	9	0·82	2	1·64	0·64	0·64	0·058	0·071
12	12	10	0·83	2	1·67	0·67	0·67	0·056	0·067
				TWO MACHINES PER SECTION.					
3	6	4	1·33	2	2·67	0·67	0·33	0·111	0·168
4	8	6	1·50	2	3·00	1·00	0·50	0·125	0·167
5	10	8	1·60	2	3·20	1·20	0·60	0·120	0·150
6	12	10	1·67	2	3·33	1·33	0·67	0·111	0·133
				THREE MACHINES PER SECTION.					
2	6	4	2·00	1	2·00	1·00	0·33	0·167	0·250
3	9	7	2·33	1	2·33	1·33	0·44	0·148	0·190
4	12	10	2·50	1	2·50	1·50	0·50	0·125	0·150
				FOUR MACHINES PER SECTION.					
2	8	6	3·00	1	3·00	1·00	0·25	0·125	0·167
3	12	10	3·33	1	3·33	1·33	0·33	0·111	0·133
				FIVE MACHINES PER SECTION.					
2	10	8	4·00	1	4·00	1·00	0·20	0·10	0·125

* In this case one reactance carries load transferred to two coupled sections. In all other cases two or more share it.

SCHEDULE B.—STAR DESIGN.

MAXIMUM VALUE OF B FOR DIFFERENT CONDITIONS.

(1) Machines per section	1	2	3	4	5
(2) Number of sections	7	5	4	3	2
(3) Transfer capacity, worst case	0·43	0·60	0·50	0·33	0·20
(4) Maximum B for 2½ per cent. difference	5	4·6	5·7	7·6	9·2
(5) Maximum B for 1½ per cent. difference in volts with machines at 50 per cent. power factor	Above 25	Above 25	9·0	16·5	Above 25
(6) Transfer capacity, one machine off	0·43	0·30	0·17	0·08	0·00
(7) Maximum B for 1½ per cent. difference in volts with machines at 80 per cent. power factor	4·0	7·2	11·5	Over 25	Over 25
(8) Maximum B for conditions (5) and (7)	4·0	7·2	9·0	16·5	Very large

SCHEDULE C.—STAR DESIGN.

SHORT-CIRCUIT FACTOR.

Machines per section	One		Two			Three			Four	
Number of sections	5	6	4	5	6	2	3	4	2	3
Number of machines	5	6	8	10	12	6	9	12	8	12
Bus reactance B	4	4	7½	7½	7½	9	9	9	16	16
			FACTOR IN TERMS OF TOTAL CAPACITY.							
Generator reactance A—										
10 per cent.	3·8	3·6	4·1	3·5	3·1	5·6	4·5	3·4	5·6	4·2
15 ,,	2·8	2·7	3·0	2·7	2·4	3·8	3·3	2·7	5·1	3·0
20 ,,	2·2	2·2	2·4	2·2	2·0	2·6	2·6	2·1	3·0	2·4
30 ,,	1·6	1·6	1·8	1·7	1·5	2·1	2·0	1·6	2·1	1·8
			FACTOR IN TERMS OF MAXIMUM OUTPUT.							
10 per cent.	6·3	5·4	5·4	4·4	3·7	8·4	5·8	4·3	7·5	5·0
15 ,,	4·7	4·1	4·0	3·3	2·9	5·8	4·2	3·2	6·8	3·6
20 ,,	3·7	3·3	3·2	2·8	2·4	4·4	3·4	2·6	4·0	2·9
30 ,,	2·7	2·5	2·4	2·1	1·9	3·0	2·4	1·9	2·8	2·1
			FACTOR IN TERMS OF SECTION CAPACITY.							
10 per cent.	19	22	16	18	19	11	14	14	11	13
15 ,,	14	16	12	14	14	8	10	11	10	9
20 ,,	11	13	10	11	12	5	8	8	6	7
30 ,,	8	10	7	9	9	4	6	6	4	5

Fig. 22 gives the results in a convenient alternative form.

Transfer of load through busbar reactances at high power factor.—When energy is transferred from one busbar section to another at a power factor higher than that of the load, the shortage of magnetizing current has to be made good by the machines connected to the section receiving energy. These machines will then be operating at a reduced power factor and consequently with a reduced energy output. Fig. 23 shows the relation between rated output and power factor typical of modern machines, and it will be seen that if the machine is rated at 100 per cent. k.v.a. at 80 per cent. power factor, then the k.v.a. output is reduced ultimately to about 80 per cent. at zero power factor.

Fig. 23. OUTPUT OF TYPICAL GENERATOR AT DIFFERENT POWER FACTORS

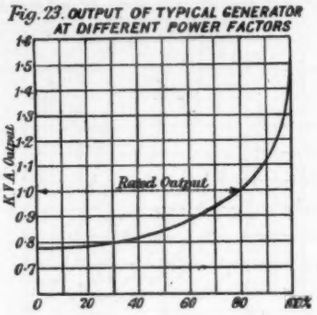


Fig. 24. VOLTAGE DIFFERENCE DUE TO TRANSFER OF LOAD

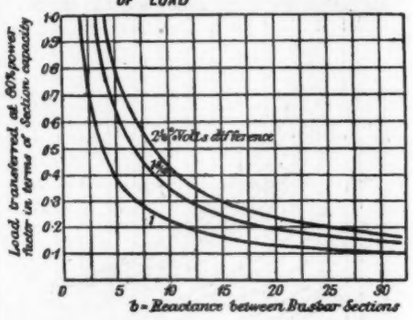
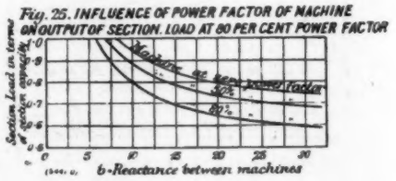


Fig. 25. INFLUENCE OF POWER FACTOR OF MACHINE ON OUTPUT OF SECTION. LOAD AT 80 PER CENT POWER FACTOR



Transfer of load through busbar reactances at high power factor.—When energy is transferred from one busbar section to another at a power factor higher than that of the load, the shortage of magnetizing current has to be made good by the machines connected to the section receiving energy. These machines will then be operating at a reduced power factor and consequently with a reduced energy output. Fig. 23 shows the relation between rated output and power factor typical of modern machines, and it will be seen that if the machine is rated at 100 per cent. k.v.a. at 80 per cent. power factor, then the k.v.a. output is reduced ultimately to about 80 per cent. at zero power factor.

Fig. 24 shows the voltage difference required for the transfer of load at 80 per cent. power factor through reactance between busbars, the reactance in this case being the effective reactance of any combination of units there may be in series and parallel between the sections in question.

Fig. 25 shows the advantage of furnishing magnetizing current from the machines running in the section to which energy is being transferred. The load is again taken at 80 per cent. power factor. The lower curve requires transfer of load at 80 per cent. power factor. With the top curve the whole current output of the machines running on the section is taken as magnetizing current. It will be seen in this case that with half the machines running, if the section output is to be three-quarters of the section capacity (*i.e.*, allowing 25 per cent. spare plant), one is limited to 11 per cent. equivalent reactance between machines, but this rapidly increases up to a theoretical limiting figure of 30 per cent. as the power factor of the running machines is decreased.

These curves are drawn for a potential difference of 1½ per cent., this figure being the drop due to the reactance. There will be a small additional drop due principally to the energy component of the load causing I R drop. This will be in general less than ½ per cent. so that the figures of 1½ and 2½ per cent. chosen correspond to a maximum difference of about 2 and 3½ volts, to a variation from normal of 1 and 1½ per cent. in volts.

We can now determine the maximum value of busbar reactances for different conditions of running. These are set forth in Schedule B. This Schedule is prepared to cover different numbers of machines per section and of sections, and covers a very wide range, because it will be found that with a given number of machines

per section, the number of sections does not exercise much effect; for in the first place one has to allow from the commencement the transfer capacity that will be necessary in the complete installation, and in the second place it will be found that if each likely combination of machines and sections is worked out in detail the maximum values of B do not vary much with the number of sections.

The third line shows the maximum load transfer required at full load in the most unfavourable case as shown in Fig. 17, and the next line shows the maximum value of B for 2½ per cent. voltage difference, the load being transferred at 80 per cent. power factor.

If we meet this extreme case by adjustment of the machine power factor we get at once a big increase in the possible amount of reactance, and with a voltage variation of 1 per cent. from normal we can get the results shown in line 5.

Generally at full load on any one section we can arrange to have not more than one machine shut down on that section, and can thus transfer at 80 per cent. power factor through much larger reactances. The figures are given in line 7.

For investigation of the limiting effect on short-circuits the author has assumed this to be the normal condition of operation, and that adjustment of power factor will be resorted to only in the extreme case and then will be limited to 50 per cent. power factor. We then get the permissible maximum B by combining lines 5 and 7. The result is shown in line 8 and does not necessitate approaching the 50 per cent. power factor limit except where there are three or four unit machines per section.

Based on these figures for B, the short-circuit factors are figured and shown in Schedule C. This factor is the figure by which the rated capacity or output, as the case may be, must be multiplied to get the maximum instantaneous output on short-circuit.

Fig. 26. CURRENT-LIMITING REACTANCE.

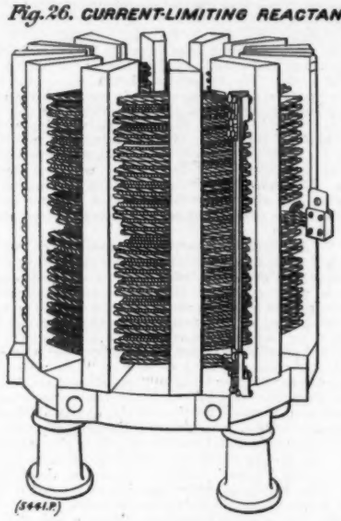


Fig. 28. DIAGRAMS SHOWING FORCE IN CONDUCTORS CARRYING CURRENT.

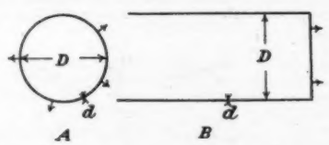
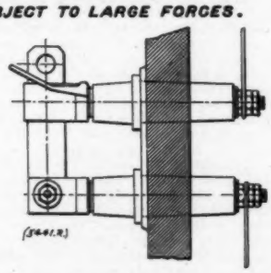


Fig. 29. TYPICAL ISOLATING SWITCH SUBJECT TO LARGE FORCES.



APPENDIX VI.

DESIGN OF CURRENT-LIMITING REACTANCES.

The special feature of reactances employed for current-limiting is that the current they have to limit on emergency is many times the maximum current they may have to carry continuously. This feature puts these reactances in a class by themselves, and must be kept in mind in comparing different designs.

There is no gain in the use of iron in the design, as in order to ensure the correct reactance under heavy currents the iron has to be worked at very low densities under normal running. In most cases the employment of iron will not give a cheaper design, but there are also other good reason for avoiding its use.

These reactances are required generally for important circuits, and principally for use in busbars, and it is important that their use should not lower the factor of safety on the system. There are great and obvious advantages in employing a design in which all parts are fully open to inspection, and this is impossible where iron is employed.

It is essential that the device shall perform its function when an emergency arises. With a closed design with iron core some defect may develop and be overlooked until failure occurs, owing to the impossibility of examining individual windings without taking the whole thing to pieces and re-building it.

Figs. 26 and 27 illustrate a reactance designed for this class of service and showing how readily all parts can be inspected. The coils are of bare copper, so there is no insulating material to give trouble. The only high-tension insulators are the very substantial ones forming the feet on which the reactance stands.

Fig. 27. SECTION OF CURRENT-LIMITING REACTANCE.

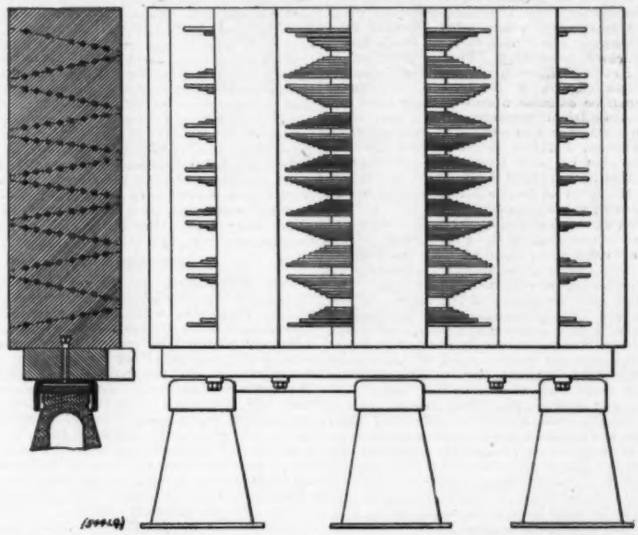


Fig. 30. TYPICAL OIL SWITCH.

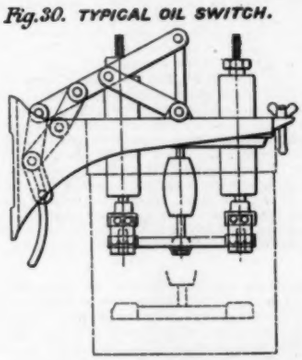
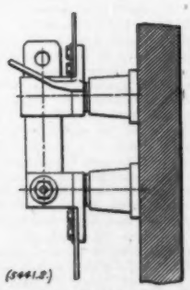


Fig. 31. TYPICAL ISOLATING SWITCH SUBJECT TO SMALL FORCES.



The coils are of circular formation calculated to withstand readily any bursting stresses, and are so well supported by the frame which is of concrete cast around the coils that they cannot become distorted. The concrete is found to give ample insulation between turns for running conditions, but if subjected to abnormal voltages due to high-frequency disturbances it absorbs current to advantage, dissipating the energy as heat.

The construction shown is one which readily admits of spacing the conductors to the best advantage, and ample ventilation, and the materials employed are non-inflammable.

A reactance of this kind installed in a brick chamber cannot break down to earth, as there is no good earth in the neighbourhood.

APPENDIX VII.

HEATING AND STRESSES DUE TO HEAVY CURRENTS.

We have now considered how the concentration of power on a fault occurring can be limited. We have yet to consider the heating and stresses due to the large currents still be to dealt with, both under normal and under faulty conditions.

Electromagnetic stresses on conductors.—In modern practice conductors in different phases may be spaced at 1-in. centres or less as in cables, or at 2-ft. centres or more as in large switchboards.

With adjacent conductors at 12-in. centres carrying current in opposite directions, the maximum repulsive force between them will be 9 lb. per foot run for 10,000 amperes, R.M.S. value. The force varies inversely as the distance and proportionally to the square of the current, and often attains serious proportions in modern practice.

In a three-phase cable carrying 100,000 amperes on a fault the force may reach a maximum of 12,000 lb. per foot run, and would approach this in the joint boxes.

Conductors spaced 1 foot apart will be subjected to 900 lb. per foot run on the same current. If the conductors are securely fixed at the ends, the stress on the end supports may be many times this. It becomes essential to support the bars in such a way as to prevent these forces from causing destruction.

A current of 100,000 amperes may be met with on the direct-current side of large rotary converters and on the low-tension side of large power transformers as well as on the high-tension circuits in very large power stations.

In current transformers designed with multiple-turn primary windings and with coils lying side by side, large forces are produced on short-circuit, tending to drive the coils apart and distort the ends if unsupported. With typical modern designs the safe limit is reached when the currents are of the same order of magnitude as indicated below also for heating limits. The transformer should not be subjected to more than 200 times normal load current.

Where a conductor forms a loop there is a force tending to expand the loop, the magnitude of which is given by the following formulæ:—

In Fig. 28 (A), $$F = \frac{9C^2}{D}\left(\log_e \frac{4D}{d} + 0{\cdot}1\right) \times 10^{-8}$$

In Fig. 28 (B), $$F = \frac{9C^2}{D}\left(\log_e \frac{2D}{d}\right) 10^{-8}$$

where F = lb. per inch.
D = inches.
C = amperes.

These cases are illustrated by Fig. 28, and, based on the figures they give, a fair estimate may be made of most cases which arise in practice.

A 300-ampere isolating switch of the type shown in Fig. 29, or an oil switch of the type shown in Fig. 30 with insulators at 10-in. centres, may have a force of 100 lb. distributed over the blade on a current of 20,000 amperes, or 600 lb. for 50,000 amperes. If the switch

be designed as in Fig. 31, the conductors will be almost in line with the blade, and the force due to the loop formation will be relatively negligible.

It is good practice to lock or latch the blades of all back-connected isolating switches on 6,000-volt plants where the output may reach 10,000 k.v.a. or upwards, and to latch all switches where the output may exceed 20,000 k.v.a. These figures are typical of what is required.

The forces acting on the conductor carrying current in the arc in a direct-current circuit-breaker with 6-in. break may be roughly estimated. When the carbons separate, the force for 10,000 amperes may be of the order of 3 lb. per inch, and when a loop of 3-in. radius is reached the force will be again something like 3 lb. per inch run.

Design of large conductors.—Up to about 2,000 amperes' capacity the design of conductors for alternating-current circuits presents no peculiarity except in machines and transformers where eddy currents may be set up in them, but above this figure "skin effect" has to be seriously considered. The skin effect in circular conductors admits of simple mathematical treatment. The figures for conductors of square cross-section can be calculated approximately from the solution for cylindrical conductors. The case of a very wide strip conductor also admits of easy solution, and by interpolation between these results one can arrive at a fair idea of what happens in rectangular conductors as usually employed for busbars and heavy conductors, in the form of laminated bars with ventilating ducts between the laminations.

As to the thickness of lamination $\frac{1}{4}$ in. is a common and convenient dimension with $\frac{1}{4}$-in. ducts. With vertical conductors the ducts should be increased where practicable to $\frac{1}{2}$ in. There is no benefit in building up alternating-current conductors of bars $\frac{1}{2}$ in. thick.

So long as the total thickness of the copper in the several laminations added together does not exceed $1\frac{1}{4}$ in., skin effect does not become serious, but above this figure it rapidly becomes a most important factor.

Additional capacity can only be got by increasing the width of the bars in some way, or alternatively by so arranging them that the inner and outer conductors are changed over so that each current stream flows through roughly equal lengths of inner and outer conductor. The bar should then be constructed of an even number of laminations, suitably separated by light insulation and space provided for the cross-over connection, which is not a very simple affair.

Where currents of the order of 5,000 amperes or upwards have to be or may have to be dealt with, it is therefore essential to provide ample room for the maximum width of strip which may be ultimately necessary and to keep down the maximum current to be dealt with, as for example by interleaving heavy incoming and outgoing circuits as in Fig. 8.

Stresses due to Heating of Conductors.—If a copper conductor is prevented from expanding and is then heated, it will exert a stress of about 240 lb. per square inch for each degree Centigrade rise of temperature. If the supports spring sufficiently to admit of expansion taking place, the stress will be limited to the amount necessary to spring the supports.

A copper busbar 10 ft. long and 2 sq. in. cross-section, able to carry, say, 2,000 amperes, will thus exert a theoretical maximum pressure of about 15 tons for a total temperature change, due to electric heating and atmospheric conditions, of 60 degrees C. This same bar for the same temperature change will increase in length by about $\frac{1}{4}$ in. This can be absorbed by deflecting the bar about an inch at the centre if it is free to move, or by the slipping of the bar on its supports. Expansion is generally taken care of by slipping. It is, however, good practice on long busbars to limit this by the use of expansion joints.

Heating Effects of Large Currents.—With the increase in the size of plant we reach limiting conditions due to heating effects, as we have on emergency conditions very high current densities to contend with. The heating effect being proportional to the square of the current quickly reaches abnormal figures. A plant may be quite safe against heating troubles and have perhaps a factor of safety of 4, but on doubling that plant the margin disappears.

If heat is generated in a conductor very rapidly there is no time for radiation, convection, and conduction to play their part, and the heat is practically wholly absorbed in the conductor, resulting in a corresponding temperature rise. Currents flowing in copper conductors at 1,000 amperes per square inch will raise the temperature 50 degrees C. per hour if the heat is all absorbed. On this basis a current of 100,000 amperes, say 1,000,000 k.v.a. on 6,000 volts, will raise the temperature of a 0.1 sq. in. cable at the initial rate of about 12,500 degrees C. per second.

Under conditions which are permissible, the insulation on conductors does in fact absorb a considerable amount of heat and the theoretical maximum temperatures are not reached. For coils wound with wire or thin strip the rise may not be more than half the theoretical figure. On average underground cables the discrepancy would be something more like 10 per cent. Using this latter margin we get the following round figures for temperature rises :—

Density.	Rate of Temperature Rise.
10,000 per sq. in.	$1\frac{1}{2}$ degrees C. per second.
100,000 ,,	125 ,, ,,
200,000 ,,	500 ,, ,,

The effect of these figures in practice will be seen by an examination of the round figures in the following table, giving the maximum permissible k.v.a. in a circuit for a current density limited to 100,000 or 125 degrees C. rise per second.

Cable.	Maximum Current.	K.v.a. at 6,000 Volts.	K.v.a. at 20,000 Volts.	K.v.a. at 30,000 Volts.
sq. in.	amps.			
0·025	2,500	25,000	85,000	125,000
0·050	5,000	50,000	175,000	250,000
0·100	10,000	100,000	350,000	500,000
0·250	25,000	250,000	850,000	1,300,000
0·500	50,000	500,000	1,750,000	2,600,000

The current values are R.M.S. values and the k.v.a. is figured three-phase.

The above figures give the initial temperature rise. The effect of the initial rise is, however, to raise the resistance of the copper conductors, the specific heat remaining steady so that the rate of rise is accelerated as it proceeds. The serious overheating of a conductor in a cable may damage the cable from end to end.

Experience with stations designed in recent years and having a maximum short-circuit current of ten times their normal rated output, has shown that it is necessary that the smallest current transformer on the main switchboard should have a carrying capacity not less than one-twentieth the station output. Current transformers of good design and much smaller than this have been known to be exploded by the heat generated on a short-circuit.

On one plant already existing in this country it has been found desirable to limit the cross-section of the smallest conductor to 0.15 sq. in. The figures given above show clearly that in the large plants now in contemplation this feature will require careful consideration.

THE SOLUBILITY OF SILICON.—The hot springs (Geysirs) frequently carry silica in solution. The silica becomes insoluble when the water issues from the ground, and coats the sources with silica, which may be delicately coloured by metallic constituents; thus the famous White and Pink Terraces of New Zealand, destroyed by the Earthquake of 1886, were created. The chemist decomposes silicates by acids and dries and heats the gelatinous silica first produced, which is thus determined and supposed to be rendered insoluble in water and acids. It has long been known, however, that even crystallised quartz is not really insoluble in water, and that silica analyses are faulty for this reason; but authorities differ considerably as to the actual solubility. In their recent investigation, V. Lenkerand, A. B. Merrill (Journal American Chemical Society December, 1917, pages 2630 to 2638) come to the conclusion that there is little, if any, difference in the final solubilities of the gelatinous and of the ignited silica. But with gelatinous silica equilibrium (saturation of the solution) is obtained in a few hours or days, whilst with ignited silica equilibrium was not quite reached in the course of months. They experimented with platinum flasks which were charged with gelatinous silica from $SiCl_4$, purified of alkali, &c., which would render the silica more soluble, and added sulphuric acid and hydrochloric acid to the water, the temperature being 25 deg. or 90 deg. C. They found that, at 90 deg., 50 cub. cm. of water dissolved 0.0214 gramme of silica; on adding hydrochloric acid to the water the solubility decreased slowly at first, finally to 0.0029 gramme; with sulphuric acid the final solubility was 0.004 gramme. Geologically the question of the solubility or resolubility of crystallised silica is of considerable importance.

NEW METHOD OF SEPARATION BY GRAVITY.—The chemist makes use in his laboratory of different liquids of different specific gravities for the purpose of separating materials by flotation. The liquid medium used must have a greater density than one of the constituents of his substance and a smaller density than the others. In preliminary tests for coal-washing plants and also in checking the performance of such plants, use is made of zinc chloride for separating coal from bony coal and slate. Commercially the use of such liquids as zinc chloride seems out of question, because they are too expensive and would enter the pores of the coal, and their subsequent removal by washing with water would be too laborious, if not hopeless. It is, however, possible to prepare suitable fluids for these separations by keeping water stirred with small grains of insoluble materials such as sand and magnetite. As long as properly agitated such a fluid paste of sand behaves like a liquid of a density reaching 1·75, in which particles of lesser density, no matter of what size, would float. Experimenting on these lines, Thomas M. Chance, of Washington D.C. (Bulletin of the American Institute of Mining Engineers, February, 1918), finds that the agitation can be produced in various ways, by the aid of paddles or rotating cones or discs, as well as by forcing water under pressure into the mixture of sand and water. The apparatus which he describes is a vertical box, 6 in. by 8 in., 20 in. high, which is provided with a false bottom; in this bottom 48 holes of $\frac{1}{16}$ in. diameter are spaced 1 in. apart. Water is introduced under a head into the space between the false bottom and the base of the box; the head is regulated by raising or lowering the tank, which a hose connects with the box. The gravity is kept at 1·4; coal lumps are dropped into the box: the good coal floats and is carried away with the overflow the bony and pyritic coal sinks. This heavy material can be retreated in a fluid of density 1·6, *e.g.* From 3 gallons to 10 gallons of water were required under a low head with sand of 80-mesh per square foot of superficial area, and the use of mechanical agitation would reduce that bulk of water. How the method would work remains to be seen; but there may be something in this new system of flotation.

THE USE OF TAR OIL FUEL IN DIESEL ENGINES.

AT a meeting of the Diesel Engine Users' Association, 19, Cadogan-gardens, London, S.W. 3, held on Thursday, March 21, Mr. J. E. Edgecombe read some notes on tar oil running with a four-cycle horizontal Diesel engine at Kingston-upon-Thames. The engine is a four-cycle, four-cylinder horizontal, of 400 brake horse-power, 100 brake horse-power per cylinder; driving a 20-ton flywheel-type alternator, with an output of 270 kw. at 2,100 volts, single-phase, 77 cycles, 0·8 power factor. It was manufactured by the M.A.N. Company, of Nurnburg, and the alternator by Siemens Brothers Dynamo Works, Stafford.

The engine was originally fitted with pilot ignition pumps, one main and one pilot ignition pump for each cylinder. It was not, therefore, necessary to make any special alterations, and in fact the exhaust valves had not been taken out since December 17, 1917, and between that date and the change over to tar oil the engine had run 915 hours. The engine had had a run on tar oil of 546 hours, less stoppages of 13 hours, making a net running time of 533 hours, during which time the units generated were 51,193. The average working was at about half of full load. Crude petroleum was used mostly for ignition oil, but during a portion of the run kerosene was used for this purpose with satisfactory results. On each of the occasions when the engine was shut down as above the flame plates and pulverisers were examined and found to be perfectly clean and in good condition.

Mr. P. A. Holliday described a method of burning tar oil which his firm, Bellis and Morcom, had patented and adopted. From the observations of early experiments it was concluded that considerable advantage would be gained if means were afforded further to assist the propagation of the flame other than by the heat derived from the compressed air in the cylinder. The chilling effect of the "blast" expansion was also more acutely felt when running on tar oil than with other fuels, owing to the slow burning properties of the former. It was therefore decided to make the experiment of pre-admitting a small portion of the charge during the compression stroke, which would thereby augment the heat of compression, and incidentally drag the remaining fuel to the needle valve seat so that upon reopening the valve the "blast" would have a less detrimental effect. The result of this experiment exceeded their highest hopes; the engine ran very steadily at no-load for some time with no misfires, and the exhaust was invisible.

A trial was then run over the whole range of loads from 0 per cent. to 10 per cent. over normal full-load rating. The cylinder compression was indicated with the engine hot by shutting off the fuel and blast, and this was found to be 495 lb. per square inch or 35 atmospheres.

Starting up on petroleum (cold engine)...	640 lb.	blast	460 lb.	per sq. in.	max. pres.
0 load tar oil	650 ,,	,,	510 ,,	,,	,,
¼ load ,,	700 ,,	,,	530 ,,	,,	,,
½ load ,,	760 ,,	,,	550 ,,	,,	,,
¾ load ,,	820 ,,	,,	570 ,,	,,	,,
Full load ,,	900 ,,	,,	600 ,,	,,	,,
Overload ,,	940 ,,	,,	640 ,,	,,	,,

Under this fuel-valve setting the engine was liable to miss occasionally in the region of no load.

Although Mr. Holliday did not wish to defend the high maximum pressures, they were not unusual in at least two other types of engines with which he was acquainted. In solid injection engines 600 lb. per square inch was quite usual. The gear as now fitted to a four-cylinder 220 brake horse-power Diesel engine of their build which is running regularly on their shop load was described as follows :—

Two fuel cam noses are fitted side by side, one for giving the valve "pilot injection" and the other being the main admission cam. Two independent rollers are fitted into the fuel valve operating levers, the one engaging with the main cam being mounted on a concentric pin, whilst the other is mounted on an eccentric portion of the same pin. These pins are linked up to a main shaft connected to the governor so that the clearance between the pilot cam and its roller varies according to the load on the engine; thus for full load it has the maximum and for no load the minimum clearance. By this arrangement the fuel-valve opening by the pilot cam is earliest on light load and gradually becomes later until maximum load is reached. It is, therefore, possible to work with a good advance for no load, and all the maximum pressures are reasonable.

Mr. G. B. Vickers stated that Messrs. Hick, Hargreaves and Co., Limited, had carried out experiments with the sleeve-type pulveriser and sharp-edge flame plates, and on an experimental engine of 240 brake horse-power they found they could run with a perfectly clear exhaust from one-third of full load to 10 per cent. overload. They had not yet been able to get below this one-third load, but hoped to do so very shortly. His firm were pinning their faith on obtaining the best possible atomisation of the fuel, and, if this was attained, they had every confidence in engines running on tar oil, even down to no load.

ABSORPTION AND PHOSPHORESCENCE. ERRATUM.—In the fifth line from the bottom of our Note on page 434 of last week's issue the word ". But" should be replaced by ", that." The last lines should thus read: the considerations conform with his view, that there are electromagnetic fields of force in the atoms which are condensed on combination and opened up in stages by the absorption of light and the action of solvents, and that reactivity depends upon these force fields.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c. of the Communicators are given in italics.

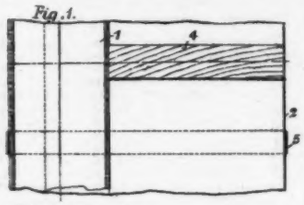
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

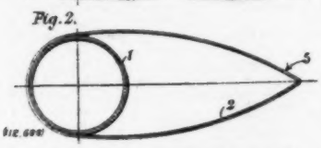
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

AERONAUTICS.

112,688. A. J. Liversedge, Westminster, London. Aircraft. (2 *Figs.*) February 12, 1917.—This invention relates to struts or other members of aircraft framework of the kind composed of metal tubes having hollow metal attachments of stream-line formation internally supported at intervals throughout their length. The invention consists of a particular construction of such struts and consists of a cylindrical tube 1, a hollow metal

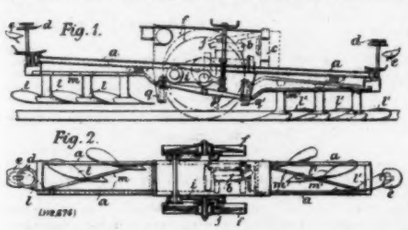




member 2 of stream-line form welded or otherwise integrally secured to the tube, internal supporting blocks 4 disposed at intervals throughout the lengths of the hollow metal member and external binding strips 5 surrounding the structure as a whole, these external binding strips being disposed at positions other than those at which the internal supporting blocks are located. (*Sealed.*)

AGRICULTURAL APPLIANCES.

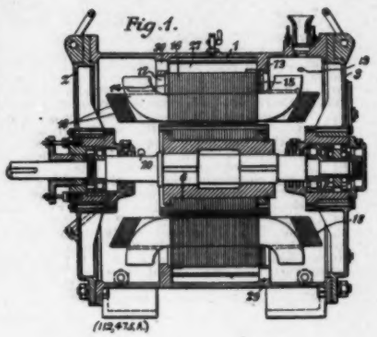
112,674. A. Wyles, Junior, and Wyles Motor Ploughs, Limited, Manchester. Motor-Driven Agricultural Implements. (2 *Figs.*) January 22, 1917.—This invention relates to motor-driven agricultural implements of the double-ended balanced variety, that is to say, in which the ploughs are disposed at both sides of the axis of the running wheels to permit of ploughing the land all one way, one set of ploughs at one side of the axis throwing the soil in one direction and the other set at the other side of the axis and in use on the return journey by the tilting of the frame, throwing the soil in the opposite direction. *a* designates the main frame of the plough carrying the engine *b*, radiator *c*, steering hand wheels *d* and drivers' seats *e*, this frame being capable of being slightly tilted to one or other side of the axis of the running wheels *f*, which are driven from the engine and one of said wheels being shown as mounted on a radial arm *i*,

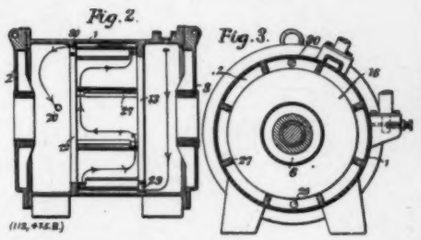


so that it may be adjusted as to height in relation to the other and to the frame as by a screw spindle *j*, co-operating with the free end of said arm and operable by a handle in order that one wheel may run in the furrow whilst the other runs on top of the land. The ploughs, of which two sets *l*, *l*1, are shown, one set at each side of the running wheels, are so arranged that each set is carried by a separate beam *m*, *m*1 respectively fulcrummed at their outer ends to the main frame *a* and free to be raised or lowered at their inner ends by being pivoted in the forked ends of a double-armed beam *p* pivoted to a frame member (not shown), and having its aforesaid forked ends co-operating with brackets *q*, *q*1, depending from the main frame *a*. At the right-hand side of Fig. 1 the beam *m*1 is shown in full lines in its lowered position with the ploughs in operative position, and in broken lines in its raised position, its inner ends being always in engagement with the guiding bracket *q*1. (*Sealed.*)

ELECTRICAL APPARATUS.

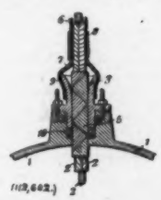
112,475. Submersible and J-L Motors, Limited, Southall, and C. W. Durnford, West Ealing. Electric Motors. (9 *Figs.*) October 10, 1916.—This invention relates to electric motors of the kind adapted to be operated submerged in water, and in which water is or can be admitted to the interior of the motor. According to one feature of this invention, a motor is so constructed that water can be circulated around the outside of the stator through the gap between the stator and rotor and through the slots in which the stator windings are placed. The motor comprises a cylindrical casing 1 closed by end plates 2 and 3. Mounted in bearings in the end plates is the rotor. Two parallel ribs 12 and 13 extend around the inside of the casing 1. Plates 14 and 15 fit into shoulders on the two ribs 12 and 13, respectively, and clamp between them the iron stampings 16 of the stator. The conductors 18 of the stator pass through slots in the stator. For the purpose of circulating water through the motor casing an inlet is provided at 19 and an outlet at 20; between the ribs 12 and 13 longitudinal ribs 27 extend, these ribs being cut away to allow water to pass therethrough. Water entering through the inlet 19 falls over the ends of the stator windings 18 and passes through an opening 29





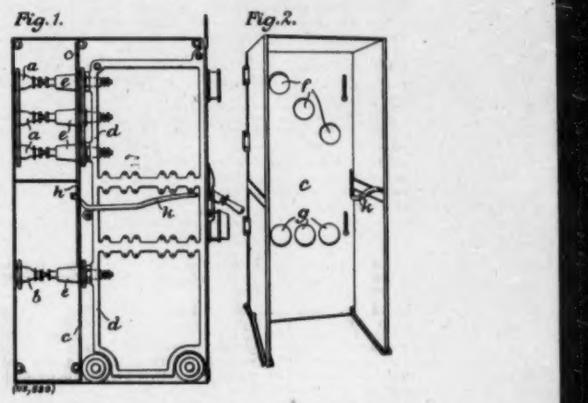
in the rib 13. The water then passes upwards on both sides of the motor through the chambers formed by the outside of the stator laminations 16, the casing 1 and the ribs 12, 13, and 27. The openings in the ribs 27 being at opposite ends of adjacent ribs, the water follows a zig-zag course until it reaches the top of the motor, when it flows through the opening 30 in the rib 12, and leaves by the outlet 20. The water also flows through the gap between the stator and rotor and through the stator slots. (*Accepted January* 23, 1918.)

112,602. Submersible and J — L Motors, Limited, Southall, and C. W. Durnford, West Ealing. Electric Motors. (2 *Figs.*) October 10, 1916.—This invention relates to submersible electric motors. According to this invention, the stator windings and the leads form continuous lengths of conductors. The motor, a part of the casing of which is shown at 1, may be of the three-phase alternating current type, and of the kind described in the Specification of Patent Application No. 112,475. The leads 2, 2, 2, form continuous lengths of conductors with the stator windings, there being no joint to the stator windings. The conductors 2, 2, 2, are led out of the motor for a considerable length (say 50 ft.) through a gland 3 in the casing 1. Each of the three conductors 2, 2, 2, is bound with a layer of vulcanising tape and strips of any suitable plastic



insulating material and cut to fit the spaces between the cables. The whole cable where it passes through the gland is bound with vulcanising tape 5, and vulcanised to form a three-core cable. This cable is covered throughout its length with a canvas tube 6. The lower end of this tube is split and brought over the mouthpiece of the gland. Another short piece of canvas tube 7 is slipped over the mouthpiece and the first-mentioned canvas tube and bindings of strong string are applied at 8 and 9. At 10 washers of any suitable plastic insulating material are provided, and by tightening up the gland these washers are compressed and expand the cable above and below the washers, thereby ensuring a tight fit for the cable in the gland. Any pull applied to the cable outside the motor casing is therefore not transmitted to the motor windings. (*Accepted January* 23, 1918).

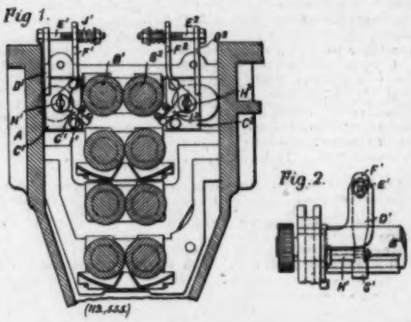
112,580. G. Pailin and Ferguson, Pailin and Co., Limited, Higher Openshaw, Manchester. Electric Switchboards. (5 *Figs.*) June 13, 1917.—This invention relates to truck-type switchboards. The invention comprises the combination with the partition or the like, in front of the electric supply terminals, having apertures therethrough for the passage of the complemental terminals carried by the truck, of a sliding shutter connected to one or more curved or shaped levers acted upon by a part or parts on the truck, so that the said partition apertures are automatically opened and closed respectively on the insertion and withdrawal of the truck. The terminals *a*, *b*, of the incoming and outgoing current are arranged at the rear portion of the cubicle, the respective sets being in separate compartments. In advance of the terminals, a partition *c* is fixed in the cubicle to isolate the terminals from the front portion of the casing which contains the truck *d* carrying the complemental terminals *e*, the oil or other switches, the measuring instruments and other usual fittings. Apertures *f*, *g*, are formed through the partition so that the complemental terminals can pass therethrough on the insertion and withdrawal of the truck *d*. The shutter *h* for the automatic opening and closing of the aforesaid apertures *f*, *g*, consists of a sliding plate placed adjacent the Partition *c* and having two apertures corresponding with two of the apertures *f*. When the shutter is in its upper position, its apertures register with the two upper partition apertures *f* and a gap in the plate uncovers the remaining aperture *f*. The truck terminals *e* can thus pass through the partition and engage the fixed terminals *a*, *b*, at the rear of the cubicle. When the shutter *h* is in the lower position, the apertures *f*, *g*, are closed thereby, so preventing access to the fixed terminals. The



shutter *h* is automatically operated by the movement of the truck *d*, and such operation is obtained by a lever *k* pivoted within the cubicle and connected with the shutter *h*. The lever is actuated by a roller mounted on the truck *d*, the lever *k* being shaped and arranged so that the shutter *h* is raised to open the partition apertures only when the truck has been pushed nearly home within the cubicle, and in like manner to ensure that the apertures are closed before the truck is fully withdrawn from the cubicle. (*Sealed.*)

MINING, METALLURGY AND METAL-WORKING.

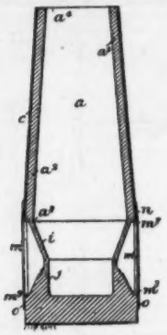
112,555. W. Gilbertson and Co., Limited, E. Griffiths, and G. Webb, Pontardawe. Manufacture of Tin Plates. (2 *Figs.*) April 2, 1917.—The invention relates to the grease pots of tinning machines, and consists in an improved device for carrying the wipers for the grease pot rolls in which a two-armed lever is pivoted substantially at the level of the axis of the roll to be wiped, the arm carrying the wipers being inclined in known manner at an angle of approximately 45 deg. to the horizontal plane containing the axis of the roll, and the other arm being connected to a vertical extension which is acted on by an adjustable spring controlling the pressure applied to the rubbing surface. A is a grease pot of which the upper part contains the grease-pot rolls B1, B2. Brackets C1, C2, are mounted on either side of the rolls in the grease pot and carry lugs D1, D2 projecting upwards; screw-threaded bolts E1, E2, pass through holes in the lugs D1, D2, and also through holes in the upper ends of arms F1, F2,



of two-armed levers F1, G1, and F2, G2. These levers are pivoted to the brackets C1, C2, on spindles H1, H2, preferably arranged at approximately the same level as the axes of the rolls B1, B2. The arms F1, F2, are vertical, or approximately vertical, and the arms G1, G2, which carry wipers I1, I2, are inclined downwards, so that the wipers engage with parts of the rolls which are below the centres and towards the adjacent sides of the pots, the wipers are set at an angle of approximately 45 deg. to the horizontal plane containing the axis of the rolls, the form of the levers adjacent to the rolls conforming substantially to the contour of the latter. In order that the wipers may engage with the rolls with a constant but adjustable pressure, springs J1, J2, are provided on the bolts E1, E2, and press the arms F1, F2, towards the sides of the pot A under a tension which is adjusted by nuts. (*Sealed.*)

112,513. W. J. Foster, Walsall. Blast Furnaces. (1 *Fig.*) January 17, 1917.—According to the invention, that part of the furnace rising above the belly to constitute the body, and whose interior provides sloping sides, is formed thinner in its walls than ordinarily, and by an external metal casing lined with suitable brickwork, and is supported from the base or hearth by a number of distanced apart T or other suitable sectioned girders applied vertically, with their ends resting on the hearth casing and their upper ends engaging beneath a suitable baseplate at the base of the body adjacent to the belly. The girders are arranged at distances apart in a circle underneath the baseplate, and when of T-section the shank web of the T extends beneath the baseplate, said web being cut away for a distance at the upper end so that the head web of the section above this cutting away faces the casing of the body and is attached thereto for some distance above the belly. The body *a* of the furnace is formed of brickwork a^2 and an enclosing metal casing *c*, and extends from the level a^3 to the level a^4. Below the level a^3 is built the bosh *i*, and below this bosh is the hearth *j*, and the invention consists in supporting the walls of the body on the hearth casing by a number of distanced-apart T girders *m*, whose upper ends m^2 engage beneath a suitable baseplate at the base of the body, and whose lower ends m^3 rest on the hearth casing,

these girders being arranged at distances apart in a circle beneath the baseplate. Said girders m are arranged a distance apart in any number in a circle, and at n and o the shank web of the T



is cut away, leaving the head web extending beyond the ends m^2, m^3, for attachment to the body casing and the hearth casing. (*Accepted January* 23, 1918.)

112,361. Ch. M. Stein and Cie., Paris, France. Cast-Iron Mixers. (2 *Figs.*) March 9, 1917.—This invention relates to mixers for cast-iron and consists of several curved rockers uniformly distributed along the lower part of the furnace or mixer and resting freely on rollers mounted on two shafts which are actuated by an electric motor, the rocking or oscillating motion of the mixer being obtained by reversing the direction of the current in the electric motor, the drive being effected by mere adhesion against the rollers supporting the apparatus.

Fig. 1.

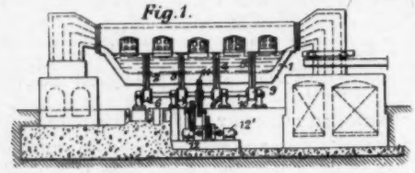
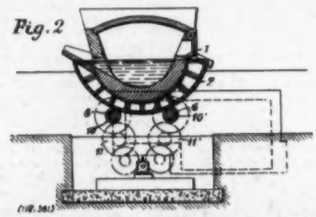


Fig. 2



The lower part of the body of the mixer 1 comprises curved rockers 2, 3, 4 and 5, placed at intervals, resting on rollers 6, 7, 8 and 9, mounted on shafts 10 and 10¹, supported by bearings fixed to the masonry. The shafts 10 and 10¹ are driven by toothed wheels 11 and 11¹, receiving their motion from two motors 12 and 12¹ through the medium of toothed wheels and pinions. The same arrangement is applicable to oscillating or tilting furnaces. (*Sealed.*)

MOTOR ROAD VEHICLES.

112,244. M. N. Knudson, Hollister, Idaho, U.S.A. Shock Absorbers. (4 *Figs.*) July 24, 1917.—This invention relates to a shock absorber for automobiles. The absorber comprises a casing 7, to which the cylinder 8 is secured. 17 is a piston located in the cylinder 8 and provided with ports 19, controlled by a valve plate. This piston is carried by a rod 20 with a ball-shaped head 24, which is adapted to engage with

Fig. 1.

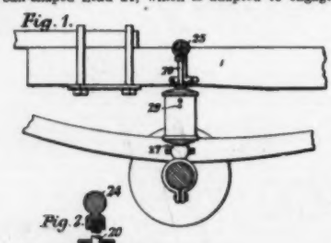
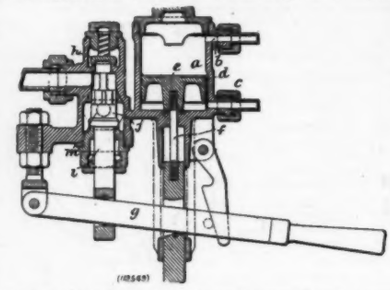


Fig. 2.

the socket 25 on the chassis 1. The bottom of the casing is provided with a similar-shaped head 26 which engages with the socket 27 on the bracket 5. 28 is a port in the cylinder above the piston, and is regulated by means of a screw plug 29. The casing is filled up to the level shown with a light oil, which also fills the cylinder. When the car strikes a rough place in the road, the piston is lowered so that the oil passes from the low part of the cylinder through the piston ports into the upper part of the cylinder, and then on the rebound of the spring the piston moves upwardly, which causes the valve plate to close so that the oil above the piston offers a resistance to the movement thereof, as said oil flowing passes through the port 28. Thus the violent return movement of the spring is prevented. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

112,549. S. T. Gresham, Hitchin, and J. M. Gresham, Knutsford (Executors of F. J. Gresham, deceased), **and G. Kiernan, Salford. Brake Mechanism.** (10 *Figs.*) March 22, 1917.—This invention relates to brake mechanism for railway vehicles. The invention comprises essentially the combination with a cylinder communicating at one end with the train pipe and at the other end with a reservoir for containing air under pressure obtained from said train pipe, and a piston in said cylinder actuated by the difference of pressure in the train pipe and reservoir, of a steam valve actuated through an arm or lever from the piston aforesaid, the said steam valve being held on its seat by the steam pressure and being opened by a plunger-like part having a portion which, when the steam valve is closed, opens communication between the steam brake cylinder and exhaust, and when the said steam valve is open, closes said communication. The air-pressure cylinder a has ports b, c, at its opposite ends communicating respectively with the train pipe and with a compressed air reservoir, the cylinder having an axial groove or slot d therein so that when the piston e approaches the end of its traverse under the action of the pressure in the train pipe, communication is established between the train pipe and air reservoir, whereby the supply of compressed air in the latter is replenished. The piston rod f, which is preferably of small cross-sectional area so as to reduce leakage thereabound, actuates an arm or lever g, which in turn actuates the steam valve h supplying steam to the steam brake cylinder. The said



valve h is held on its seat by the steam pressure, and is moved therefrom by a plunger-like part i, having a piston-like portion j adapted, when the steam valve h is open, to cut off communication between the conduit k leading to the steam-brake cylinder and the port m leading to exhaust, and when the steam valve is closed, to open such communication. With the arrangement aforesaid, when the air pressure in the train pipe is reduced for the purpose of applying the air brakes, the pressure in the reservoir moves the piston e in the air-pressure cylinder a towards the train-pipe end of the same. This piston then moves the arm g, which actuates the plunger i and the steam valve h, causing the opening of the latter and the application of the steam brakes. To take off the brakes, the pressure in the train pipe is increased to the pressure in the reservoir, when the piston e moves in a reverse direction, and the steam valve h is allowed to close under the steam pressure thereon. The steam from the steam-brake cylinder then escapes to the exhaust port m. The pressure of the steam acting on the piston-like portion j of the plunger i, which opens the steam valve h, serves to partially balance the pressure in the air reservoir acting on the piston e in the air-pressure cylinder a, so that the degree of application of the steam brake (due to the opening of the steam valve h) is regulated in accordance with the degree of application of the air brake, for if the steam pressure becomes sufficient to overbalance the effective air pressure tending to apply the brakes, the steam valve is closed and the steam-brake cylinder placed in communication with exhaust. (*Sealed.*)

SHIPS AND NAUTICAL APPLIANCES.

112,496. J. Stone and Co., Limited, Deptford, and G. H. Reed, Brockley. Bulkhead Doors. (8 *Figs.*) January 6, 1917.—According to this invention, the transmission of the door movement to the footplate is effected by toothed

Fig. 1.

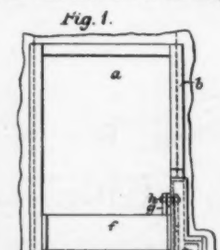


Fig. 2.

Fig. 4.

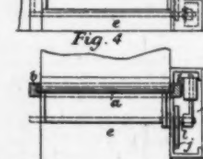
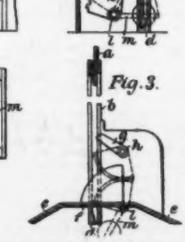


Fig. 3.



gearing operated by the sliding door during a predetermined travel of the door in one direction. a is a vertically-sliding door movable in the vertical guides b in the door frame. Usually the bottom bar or sill d of a ship's bulkhead door framing is above the plane of the floor, and the latter is formed with inclines e to facilitate traffic through the doorway. As the framing b, d, is usually made of gunmetal to allow of easy running and accurate seating of the door, the bottom bar d is liable to become injured by traffic through the doorway and the groove therein is liable to become obstructed or injured, consequently footplates f have been used for covering the bars d and closing the opening in the floor during such times as the door a is in the open position. The mechanism provided, according to these improvements for automatically operating the footplate f by the action of the door itself, comprises an arm g, the free end of which projects into the path of the door, as seen in Fig. 3. The arm g is fixed to a spindle h, upon which is keyed a toothed quadrant j, the latter meshing with a quadrant k keyed to the spindle l. The hinged footplate f is mounted on the spindle l so as to turn therewith. The spindle l may be fitted with a weighted arm m, the action of which is to lower the footplate f to the position seen in Fig. 3, when the door is raised and consequently to raise the arm g. Naturally, the weight of the footplate itself may be used for lowering it from the raised position seen in Fig. 2, seeing that this plate need not be raised into a vertical plane, or on a dead centre, when the door closes. In operation, and assuming the parts to be in the position seen in Fig. 3, during the descent of the door a to the closed position, the lower edge of the door strikes the end of the arm g projecting into its path and depresses the arm g into the chainline position. The consequent quarter-turn of the spindle h and quadrant j is transmitted to the quadrant k and spindle l, with the result that the footplate f is turned upwardly to the position seen in dotted lines m, in Fig. 2, the parts being so designed that the footplate f is clear of the path of the door a before the door can strike the plate f. Upon raising the door, the footplate f is automatically returned to the position seen in Fig. 3, by one of the means above described, as soon as the door has risen sufficiently to permit the arm g to move. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

112,735. The Stirling Boiler Company, Limited, Westminster, and D. B. Brearley, Barrow-in-Furness. Steam Generators. (2 *Figs.*) July 6, 1917.—This invention relates to an arrangement of means for cooling down boilers. As shown, the wall A of the boiler adjacent the mud drum B is formed with a passage C fitted with a damper D, said passage communicating at one end with the space E between the drum end and the usual air seal plate F fitted to the outside wall of the boiler around the drum end and communicating at the other end with the outlet flue G leading to the chimney at a point beyond the usual damper H. To cool the boiler, after is it blown down, the air seal plate F is removed, the manhole cover in the mud drum end

Fig. 1.

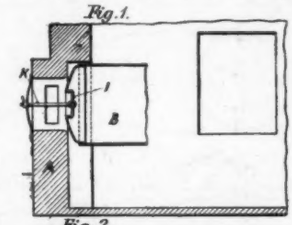
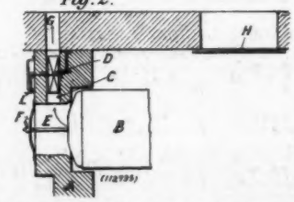


Fig. 2.



is knocked in, and the air seal plate F replaced, being then held in position by substituting for the manhole cover a temporary clamp I bridging the manhole and bolting the seal plate F thereto by means of a temporary tiebolt K. The usual damper H in the outlet flue is closed, and the damper D in the passage C is now opened by means of the handle L. The draught in the flue causes cold air to be drawn into the boiler and to circulate through the drums and tubes and to pass off through the mud drum B to the outlet flue in the direction indicated by the arrows, thereby rapidly cooling the boiler. In certain boilers air seals are not fitted to the outside walls round the mud drums ends, and in such cases a temporary air seal plate is required. (*Sealed*).

RADIOTELEGRAPHIC STATION AT KARLSBORG, SWEDEN.—The radiotelegraphic station recently erected at Karlsborg will, with its range of 5,000 km., rank with the largest installations of its kind. Karlsborg is a comparatively modern fortified town, barely a century old, situated in the southern part of Sweden, on the Vanäs rocks of the western shore of Lake Wetter, about half-way between Stockholm and Götheborg, on the main railway line. The two masts, 210 m. high, weigh only 25 tons each, which is a very small weight. They rest on insulating blocks of a fine-grained black granite which is impregnated with paraffin; further to improve the insulation the masts are built up of five insulated sections. The antenna is formed by 60 wires of phosphor-bronze, 450 m. long, which are suspended between a pair of six-armed devices. Spiral springs and insulators are inserted in the end connections, the former to protect the wires in storms and when loaded with snow. A network of "earth-balance" wires is stretched over the 95 hectares of rocky ground, 5 m. above it, to facilitate the tuning of the system; the wire is also phosphor-bronze, 1 mm. in diameter; there is no earth connection. Current is obtained at 15,000 cycles from the Trollhättan hydro-electric power station; steam power is provided on the site as a reserve. The engineers chiefly connected with the work are Mr. R. Rendahl and Professor Karl Ljungberg; the latter designed the antennæ masts, which were built on the site and erected in the finished condition, a very noteworthy piece of engineering. A smaller plant has also been provided at Karlsborg for the local radiotelegraphic traffic.